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The first issue of				1888	cont'ined	175	different adv'ts.
1881	contained	28	different adv'ts.	1889	"	234	" "
1882	"	45	" "	1890	"	289	" "
1883	"	63	" "	1891	"	325	" "
1884	"	82	" "	1892	"	316	" "
1885	"	100	" "	1893	"	317	" "
1886	"	138	" "				
1887	"	154	" "				

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Correspondence, views and opinions on all topics within the province of this journal are cordially invited from any part of the world. We will thank readers to forward to us—**promptly** as they occur—**Items of News,** or information relating to any application of Electricity, also marked copies of their local papers containing anything likely to interest electricians. Anonymous communications cannot be noticed, nor can rejected manuscript be returned unless accompanied by the necessary postage when received.

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Transformers vs. Low Tension Distribution. DR. FLEMING, in his recent valuable researches, in comparing the high tension transformer system with that using low tension continuous currents, shows that for a distance of one mile the former can be installed for half and maintained for less, requiring also a much smaller plant. It cannot help being a satisfaction to American engineers to see that the practice in this country is thus confirmed.

Open vs. Closed Circuit Transformers; Concluded. AT last the much discussed question of closed vs. open circuit transformers appears to be definitely settled and it is hoped that it will not come up again. From his exhaustive set of tests Dr. Fleming concludes that the closed circuit transformer is by far the more economical of the two in practice. If there still exist theories to the contrary, then so much the worse for the theories. It gives us pleasure to note that Americans have been on the right track in adhering to the closed circuit type.

Repairing Incandescent Lamps. IT is stated that a German firm have made quite a success of renewing burnt-out incandescent lamps by opening the globe at the top, renewing the filament, cleaning the globe and sealing it again. In this country the question arises, Would "repairing" a lamp in this manner be an infringement on the Edison patent? in other words, Could a worn-out patented machine, for instance, be repaired by a mechanic without infringing the patent? If this is allowed by law, a remunerative lamp repairing business might be developed in this country until the lamp patents run out.

Convention Numbers of The Electrical World. THE largest number of an electrical journal ever published was that of THE ELECTRICAL WORLD dated Sept. 19, 1891. This consisted of an even 100 pages, and contained 60 pages of advertising. The present issue, however, contains 62 pages of advertising, as against 54 pages in the convention report of a year ago. The number of advertisements in the February or March convention issues for the last five years was as follows: March 2, 1889, 317; Feb. 22, 1890, 330; Feb. 28, 1891, 370; March 5, 1892, 348, and in this issue, March 11, 1893, 393, the largest number of advertisements ever published in a single issue of an electrical journal. Surely this is a remarkable showing for this year, in view of the unsettled condition of electrical matters at the present time.

The Retiring President. THE retiring president of the National Electric Light Association, Mr. Jas. I. Ayer, like the outgoing president of this great country of ours, after having been elevated to the highest position in the gift of his constituents, which he has so signally honored by his great tact, good judgment and executive skill, retires again, filled with honors, to private life. He retires not, however, to "innocuous desuetude" but to that more active participation in the councils of the Association from which the presiding officer is debarred by virtue of his official position. To his great energy and executive skill, combined with his large personality, is due in the greatest measure the marked success of the Convention, and he takes with him in his retirement to more active duties, if we may use the expression, the good will and best wishes of his hosts of friends.

The Incoming President. THE gentleman upon whom Mr. Ayer's ample mantle has fallen, is too well known to the fraternity to require at our hands further introduction at this time than the mere mention of his name. Those who have been favored with his personal friendship as well as those who have known him less intimately, are well aware of the qualifications that have led to his selection for the most honored and responsible position in the gift of the Association. It may be that in the sequence of coming events a jurist as well as a business man and an electrician may be needed to pilot the ship over the breakers, and should such a contingency arise he will be the man for the occasion. We drink to the health of the incoming president, whose "counterfeit presentment" we give on the next page, and wish him the success, which he is sure to achieve. Here's to you, Judge E. A. Armstrong. of Camden, N. J.:

Transmission of Power. PROF. UNWIN'S recent lectures in London on the transmission of power, published in the London *Electrician*, are exceedingly interesting, and give much valuable information on the subject of the transmission by means of water, ropes and air, which those interested in introducing electric transmission will do well to study, in order to see the relative advantages and disadvantages, as also the limitations of these methods, compared with the electrical. But it should be remembered that Prof. Unwin is a recognized authority on the former only; in making comparisons of those with electrical transmission it will, therefore, be well to consult an electrical engineer who is as well posted in the electrical field as Prof. Unwin is in his. Prof. Unwin is an able defender of the older systems which formerly had a monopoly of this field, but are now meeting with a very formidable rival which is rapidly replacing them, even where least expected.

The Proceedings. THE character of the papers read at the St Louis Convention was exceptionally high, and mark a distinct step in advance in the already high standard reached by those read at preceding conventions. But the three events that were most prominent through the interest attracted were the paper by Prof. Forbes, on "Thermal Storage for Central Stations," "The Incandescent Lamp from a Commercial Standpoint," by Mr. Calvert Townley, and the discussion which followed, involving the present lamp situation, and Mr. Nikola Tesla's lecture. The latter is the only one of the three that does not appear in this issue, but will be given next week with appropriate illustrations. The occasion of this lecture must be a memorable one in the history of the association, for never before has such an audience greeted one of its lecturers as that which gathered at the Grand Music Hall to hear Mr. Tesla on Wednesday evening, March 1. We will not attempt to outline Mr. Tesla's remarks at this time, nor to comment on the rest of the papers, for they are given in detail elsewhere. There is not one that will not prove interesting and profitable reading, and we commend their perusal by those not fortunate enough to have heard them.

The Congress. THE report of the Committee of the American Institute of Electrical Engineers has now appeared in the foreign journals, and we note with pleasure that it is given due prominence and that in general it appears to meet with favor, at least at the hands of the editors. How it will fare with those who may have an axe to grind remains to be seen. But from present appearances it is not improbable that the suggestions may, with unimportant changes, be adopted. That no important objections are being made to it may be taken as a sign of approval, for with such good opportunities as afforded by that committee to enable the whole electrical fraternity to discuss the subject, any one who has any criticism or suggestions to offer ought to have made them by this time, or at least ought to make them at once. No one has a right to complain later on if he has not taken the trouble to publish his criticisms now. It would, in fact, be a sure sign of weakness if any one reserves his views and suggestions until it is too late to have them discussed before the public in the electrical journals. Mr. Hospitalier's promised criticisms are awaited with interest; they will doubtless be severe and well worth reading, but we fear his hopes regarding strict theoretical accuracy in the use of terms will not be acceptable to the electrical fraternity.

The Electric Light Convention Bulletins. THE success of THE ELECTRICAL WORLD daily bulletins at the St. Louis Convention was more than assured after the appearance of the first number, which was distributed at the Southern Hotel before breakfast on Tuesday morning. The first edition of 300 copies was soon exhausted and was followed during the day by two other editions of 200 and 300 copies each. The second number was issued at the same time on Wednesday morning, the first edition comprising 500 copies and the second 400 additional. In the afternoon of Wednesday an extra number was put on the press and by supper time copies were received at the hotel. This edition comprised 4,000 copies, 3,000 of which, all that were off the press in time, were distributed at the Tesla lecture, but so great was the demand that it could not be half supplied. Thursday morning the fourth number was issued on time, with a first edition of 500, followed by a second of 400 copies, and on Friday the edition ordered was 7,000 copies. The leading features of these bulletins were, for Tuesday, Salutation, Programme St. Louis Convention, Reception and Entertainment Programme, the Electrical Special from New York and List of Attendance. In all the succeeding numbers the programmes and list of attendance was continued, revised up to date, and a review of the previous day's proceedings was added, together with Convention Notes and new announcements. The special articles were, for Wednesday morning, "The Chicago Special;" for Wednesday evening, "A Biography of Nikola Tesla;" for Thursday morning, "The Tesla Lecture;" for Friday morning, "Valediction," "A Worthy Tribute Worthily Bestowed," and a general review of the programmes and proceedings occupied a four-page edition. Every number was issued promptly on time and was eagerly sought after by those in attendance.

Underground Electric Roads. ALTHOUGH America deserves the credit for having developed the practical overhead trolley road, to England belongs the credit of having constructed the first underground electic road for rapid transit in a city. This bold attempt has proved to be such a success that it is to be followed by a similar road in other cities—which cities we regret to have to admit are all European. There is certainly no lack of enterprise for capital here, nor are we in America in want of able engineers, and as to the need of such roads, there is little doubt that it is far greater here than in the European cities Most, if not all, of the largest European cities spread out equally in all directions; the available areas, therefore, increase as the squares of the distances; but in many of our American cities there is room to spread out in only one or two directions, and the growth must, therefore, extend much further from the hearts of the cities. There is, therefore, much greater need for rapid transit, while at the same time there is much greater probability of its yielding better returns. The Brooklyn Bridge is an illustration of a single channel for the exodus of the people from the heart of a large city. The reason why so little progress is being made here is doubtless that our city fathers have too great a personal or political interest, and too little interest in the public welfare. If such roads could be made to pay for the enormous amount of "boodle," besides paying an attractive dividend to the inventors, they would doubtless soon become very numerous. Meanwhile, however, the public in general, who do not read the electrical papers, are under the erroneous impression that the difficulty lies with the electrical system. Trolley roads owe their wide spread of introduction to no small extent to the fact that the profits are sufficiently great to enable our city fathers to "come in" for a considerable amount of "boodle."

The National Electric Light Convention.

The National Electric Light Convention at St. Louis, so long in contemplation, and of which so much was expected, is now a matter of history, and has fulfilled the rosiest anticipations of its most enthusiastic friends. Never before in the history of of the Association have the attendants on the Convention confined themselves so strictly to business as on the occasion now under review, nor has the interest ever been so fully maintained to the last as at St. Louis. While there has been a larger attendance, perhaps, at previous conventions, it is doubtful if at any it has been so representative of all portions of the country as in this one. No word of praise is needed at this point for the papers, for they speak for themselves; and the discussions which followed, which for the most part are given in full elsewhere, evince the importance of the subjects and the interest excited by the methods with which they were handled by their several authors. As regards the arrangements both at this end and that, there was nothing omitted that the most fastidious could desire. As hosts, our St. Louis friends had a difficult task to perform not to fall short of the high record of their own making. So gracefully did the self-imposed duty of host fit their shoulders that they compelled us to feel that they themselves were being entertained, though themselves the entertainers. The welcome of Mayor Noonan struck the keynote of the situation when he said: "The city is yours; do with it as you like," or words to that effect. This kind invitation seemed so genuine that the visitors took it at its face value; and now that the affair is all over, we find that what we wanted to do was what most pleased our hosts to have us do, or that what they wanted us to do was just what we most desired —we don't know which it was, but the result was the same. We were royally entertained and the recollection of the event must ever remain one of the pleasantest on the tablets of our memory.

St. Louis' Hospitality.

St. Louis has again added to the well-earned reputation of the West for the hospitality she extends to visitors and strangers within her gates. None have more reason to remember this trip to St. Louis than have the ladies who accompanied the party from New York and elsewhere. No sooner had they arrived and gotten rested from their trip, than they were taken in hand by the ladies of St. Louis, and from that time on were continuously entertained in ways which are so dear to the female sex and so well understood by the ladies of St. Louis. With the crowded condition of our columns this week, we should fail if we attempted to do justice to these ladies who made our ladies their guests, and we will be pardoned under the circumstances, we feel, if we attempt no more than a mere cata logue of the pleasures provided by our generous hosts.

On the afternoon of Tuesday, Feb. 28, the ladies' committee assembled in the parlors of the Southern Hotel and escorted their visitors around to the various stores of interest, and thence to the *Post-Dispatch* and the *Globe-Democrat* newspaper offices. In regard to the former, the visitors doubtless considered themselves connoisseurs; in regard to the making of great newspapers, however, they confessed themselves novices. Having completed this circuit they were given a delightful lunch at the Electric Club. In the evening they were taken to see Willard in "The Middleman" at the Olympic Theatre, where four boxes were placed at their disposal.

On Wednesday, starting from the Southern Hotel and from the Electric Club, they were taken to the Art Museum, where its choice collection of articles of art and *vertu* gave much enjoyment. From there they were driven to the bridge and thence to the residence of Mr. James I. Ayer, where they sat down to an elegant lunch given in their honor by Mrs. Ayer. Later they took a ride over the St. Louis & Suburban Railway through the beautiful suburbs it traverses, and at four o'clock met again in the parlors of the Southern Hotel by invitation from Mr. Issertel, of the A, B, C. Co., who in honor of the anniversary of the incorporation of his company presented each lady with a corsage bouquet to wear at Mr. Tesla's lecture in the evening.

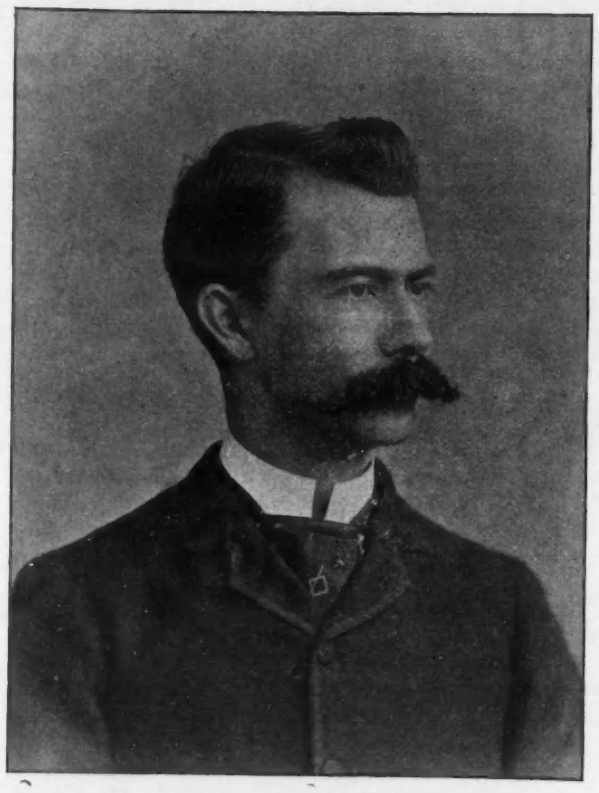
On Thursday, Capt. McCulloch, in honor of the ladies, had prepared a special cable train decorated with the colors of the Electric Club and with flags, and in this took the whole party of ladies—not gentlemen, mind you—to the Anheuser-Busch and Lemp breweries. Elegant bouquets were also presented by Capt. McCulloch. Returning from the breweries they lunched again at the club at 2 P. M., and at 2:30 they entered carriages and were driven to Shaw's Garden and to Tower Grove Park. At 6:30 P. M. they were tendered a reception at the Boatmen's Bank, Mr. W. H. Thompson, the cashier, doing the honors of the occasion. This reception was given in honor of Mrs. A. J. De Camp and Miss Cumings, daughters of J. K. Cumings, president of the Tenth National Bank of Philadelphia, who were members of the party from the East. After this reception the ladies were driven to the Grand Opera House, here they enjoyed Fanny Davenport in "Cleopatra."

On Friday such of the delegates as had not started for home the night before gathered at the Electric Club and proceeded thence by the Suburban Railroad to De Hodiamont, where they were shown through the electricpo wer station. From there they went to Normandy, and then to Forest Park, where carriages awaited them. After driving through the park they brought up at the Jockey Club in the Fair Grounds, where they were treated to what was called an informal banquet. The informality seemed to consist principally in the fact that ladies as well as gentlemen joined in the feast. From the uninterrupted buzz of conversation during the dinner, and from the delighted expression on every faee, it was very evident that each one of the 250 present thoroughly enjoyed the occasion.

Ex-Congressman Nat Frank was the toastmaster. In introducing the new president, he referred, among other things, to thermal heat. Judge Armstrong, in replying, said that every delegate had acquired, while in St. Louis, thermal heat enough to last through a cold winter. The other speakers were Messrs Ayer, Baker, Weston, Hammer, Prof. Nipher, Mrs. Francisco and Mr. De Camp.

About five o'clock the banqueters re-entered their carriages, and were driven to the Southern Hotel, entirely charmed with their outing, and with the attentions that had been showered upon them during their stay in St. Louis.

Among ladies in attendance at the St. Louis convention of the N. E. L. A. and who were recipients of the generous St. Louis hospitality were Mrs. Jno. Turner, Mrs. C. J. Foust, Cincinnati, O.; Miss Annie E. Fortiner, Mrs. D. H. Ogden, Mrs. W. H. McKinlock, Mrs. F. A. Wunder, Chicago; Mrs. A. H. Manwaring, Miss Clara M. Cuming, Mrs. A. J. De Camp, Miss De Camp, Philadelphia; Mrs. G. A. Redman, Mrs. J. H. Quine, Rochester, N. Y.; Mrs. G. M. Myers, Kansas City, Mo.; Mrs. Wm. E. Hinchleff, Mrs M. A. Beal, Rockford, Ill.; Mrs. L. A. Beebe, Hutchison, Kan.; Mrs. M. J. Francisco, Rutland, Vt.; Mrs. L. Cassier, Mrs. G. T. Manson, Brooklyn, N. Y.; Mrs. C. W. Grant, Davenport, Ia.; Mrs. W. B. Austin, Renssalaer, Ind.; Mrs. M. A. Burleigh, Mrs. J. J. Burleigh, Miss E. W. Armstrong, Miss C. W. Morgan, Camden, N. J.



Hon. E. A. Armstrong, President of the National Electric Light Association.

Those of the St. Louis ladies most active in entertaining the visiting ladies of the N. E. L. A. were Mrs. J. I. Ayer, Mrs. W. L. B. G. Allen, Mrs. T. N. Ambler, Mrs. Robt. McCulloch, Mrs. Jno. Seigrist, Jr., Mrs. Henry O'Neil, Mrs. E. J. Bagnall, Mrs. Geo. A. Rowley, Miss Rowley, Miss E. E. Nahm, Misses Schultz, Miss Bartz.

TOASTS BY THE LADIES.

The ladies of the N. E. L. A. Association, at a committee meeting held in the parlors of the Southern Hotel, March 3, 1893, adopted the following resolution:

Resolved, That the ladies of the N. E. L. A. desire to express their thanks to the ladies of St. Louis—wives, sisters and sweethearts of the members of the St. Louis Electric Club.

To entertain graciously is one of woman's highest prerogatives. The Garden of Eden had no hostess till the advent of Eve, and you all know what work Adam made of it alone. He had to get a questionable person to pass his apples for him. Now, the city of St. Louis has been made an Eden to us by the unceasing efforts of its ladies. We know not how to express our appreciation, but give us an opportunity in any city of the East, Middle or Western States to entertain you in return, and we will try to prove our gratitude. Our latch string shall be out and our hearts open to ladies of St. Louis forever.

The Boatman's Bank: May it flourish till the last Boatman has crossed over the river and on the other side may it find treasures untold deposited to its credit.

Mrs. M. J. Francisco.

In the name of the ladies of the N. E. L. A.

At a lunch given by the ladies of St. Louis to the ladies of the N. E. L. A. at the Electric Club rooms, the following toast was offered by Mrs. M. J. Francisco in behalf of the visiting ladies:

The St. Louis Electric Club: May their homes be as well illumined by love light as their club is by electric light, and may neither know grounds, short circuits or crosses.

A Pleasant Event.

One of the pleasantest incidents of this most enjoyable convention was the presentation on Wednesday afternoon to Mr. C. O. Baker, Jr., Master of Transportation, of a magnificent gold lined silver punch bowl and ladle by a few of his many friends, chiefly those forming the New York contingent. These too, jealous of the honor and pleasure to let others contribute, secretly banded themselves together and authoritatively summoned the gentleman mentioned before them, as if to reprove him for some omission or dereliction of duty. Half past five was the hour, and the ladies' parlor in the Southern Hotel was the place. Mr. Baker was led into the parlor on the plea that some one wished to see him on important business, and it was evident from his appearance that he was totally unprepared for what was to follow. Mr T. C. Martin, the spokesman, at once mounted a chair, and read the following well-chosen words, which are self-explanatory. Notwithstanding his surprise, Mr. Baker was equal to the occasion, and happily responded. We cannot quote his words, for they were not taken stenographically, nor were they prepared beforehand and copies distributed to the press. But one of the nice things he said was that he would have to call upon his friends to show him how the bowl was to be used; his friends had anticipated this, however, and through Mr. Martin invited Mr. Baker to join them in the gentlemen's parlor, where refreshments were served, and where they pledged again their friendship in bumpers of champagne to their worthy guest.

St. Louis, Mo., March 1, 1893.

To Cyrus O. Baker, Jr., Esq.:

The undersigned, passengers by the "Electrical Special" from New York to St. Louis to attend the sixteenth convention of the National Electric Light Association, beg to tender you the accompanying punch bowl as an expression of their high appreciation of your efforts and success as Master of Transportation. They realize that on this, as on so many similar occasions, the pleasure and comfort of the journey have been largely, if not wholly, due to your care, thought and personal sacrifice, and they seek this means, inadequate though it be, of conveying to you, in permanent form, the good will and affection of those who have been for several years past, and still are, your indebted admirers. They deem it well within bounds to say that the zeal and ability shown by you in this wearisome and disinterested work have contributed in a marked degree to the prosperity of the Association and the largeness of the attendance at its successive gatherings.

[Signed:]

C. S. Haley,
P. C. Ackerman,
Fred W. Royce,
C. F. McIntire,
E. W. Seymour,
Wm. J. Hammer,
W. J. Morrison,
James Ferguson,
Louis Bell,
B. E. Greene,
Geo. J. Jackson,
W. C. Bryant,
Frank C. Mason,
E. C. Young,
M. J. Francisco,
W. J. Johnston,
M. E. Baird,
Chas. W. Price,
E. B. Hatch,
John A. Seely,
J. H. Mason,
W. D. Packard,
Henry B. Cutter,
Frank A. Magee,
T. Carpenter Smith,
William Smith Harvey,
H. M. Swetland,
E E. Wood,
C. H. L. Jones,
L. C. Whitney,
J. C. Pierrez,
A. J. DeCamp
T. C. Martin,
C. E. Carpenter,
H. H. Fairbanks,
H. C. Adams,
F. R. Colvin,
Geo. T. Manson,
E. G. Bernard,
Benj. R. Western,
James A. Pentz,
J. D. Miller,
Augustus Noll,
H. J. Smith,
A. L. Newton,
C. E. Newton,
W. F. Osborne,
Chas. D. Shain,
R. B. Corey,
E. F. Peck,
H. F. Richards,
R. O. Heinrich,
J. B. Taltavall,
Fremont Wilson,
Wilson S. Howells
Nelson W. Perry,
Louis Cassier,
A. H. Manwaring.

An Invitation to the Far West.

The following invitation extended to the members of the National Electric Light Association through Dr. E. C. Kilbourne, of Seattle, Wash., to hold the next annual convention at that place, may prove of interest at this time.

Gentlemen: On behalf of the citizens of Seattle, I desire to extend to the National Electric Light Association a most cordial invitation to hold the next regular annual meeting of the association at Seattle.

I will guarantee that the following propositions will be fulfilled to the entire satisfaction of the members of the association:

A hall within convenient distance from the principal hotels having proper acoustic properties, and of the right size, quiet, being away from the noise of the street, will be provided. Adjoining this hall on the same floor will also be provided rooms for the secretary, committees and other purposes; and the hall for exhibition purposes for the use of manufacturers, supply men, and their agents in which to show their apparatus and supplies. In this room will be brought wires conducting currents of 110 volt, 240 volt and 500 volt continuous current, 10-ampere constant current and 52 volt and 104 volt alternating current. From the moment all delegates to the association place their feet on Seattle soil until they take their departure therefrom every necessary expense will be met by the people of Seattle.

Besides this, the citizens will take great pleasure in extending to you in their own Western manner the hospitalities of the city.

Arrangements will be made with the railroads for the reduced fares, with an option of five routes going or coming.

Report of the St. Louis National Electric Light Convention.

The sixteenth meeting of the National Electric Light Association was held in the Bell Telephone Building, Olive and Tenth streets, St. Louis, Mo., Feb. 28 and March 1 and 2, 1893.

President Ayer called the meeting to order at 10:45 on Tuesday morning, and introduced Hon. E. A. Noonan, Mayor of St. Louis, who welcomed the delegates as follows:

Mr. President and Gentlemen of the Convention: In the four years of my official term I have had occasion to address bodies of gentlemen representing in convention the great forces, I might say, of modern civilization; but at no time have I had the pleasure to address those concerned in what, to my mind, is now the greatest, the most wonderful, the most far-reaching, of all forces known to man—the force of electricity. Like a bold gleam of lightning, it is illuminating and dazzling the modern world. Its lustre is being shed upon all the actions of man. It has changed the methods and manners of the ways of man. It has added force and power, where force and power heretofore was impracticable. It is bringing into service much that heretofore was either out of service, or not fully within the service of man, because of the inability to accomplish the ends through the medium of steam. And to where and what extent it will carry us is a problem not within the vision even of the wizards of your profession.

You have come together in council in the greatest electric city of the world. (Applause.) Although somewhat in the far West, from where energy is supposed to reside—along the Atlantic seaboard—although we are in a great valley, where we are charged with lethargy and the taint of the lassitude that comes with a Southern breeze, notwithstanding that, we find in this city, of more than half a million people, the greatest electric plants in the world. The birth of this great power took place before the Christian era; I am wrong—it was born with the primitive and primeval forces—it was born when light was born—when Ayer came. (Applause.) I mean to say that it was discovered, or rather known to men earlier than the Christian era, but that its development is modern.

I will not delay this representative body of gentlemen. You are familiar with the subject; you are masters of a science that, to the layman, is much of a mystery. Neither time nor opportunity has permitted me to become, even in the way of an amateur, familiar enough with the subject to warrant me to go any distance into that strange and remarkable field. Therefore, permit me modestly to retire from it, and leave it where it belongs—to the men who have mastered it, who are making it the study of their lives, who are giving to it all that the artist can give, all that the enthusiast does give. Let me rather go into the channel which I should follow—the channel that brings me here—the channel of hospitality, of reception, of entertainment.

I represent the people of St. Louis. On this occasion especially have the public press announced, and in a hundred different ways it has come to me, that so far as this particular convention is concerned St. Louis will outdo herself in making life pleasant and agreeable for the gentlemen who have come here to deliberate in our midst upon these important matters. (Applause.)

Now, gentlemen, in all seriousness, this is the most important convention, in my humble judgment, that St. Louis has ever had; not in numbers of delegates, not in the great acclaim that has attended your arrival, but in the light of what you represent, in the sense of what will be accomplished by reason of your sessions here. I have found it well in my public experience to hide my ignorance on subjects with which I was not familiar by being as brief as possible. I was caught this morning by your committee reading an elementary book on electricity. It told me all about Mr. Faraday, one of the greatest men of all times, about our good, kind and lovely philosopher Benjamin Franklin, and about the different discoveries of the past, but it shed very little light upon the developments of the past ten or twenty years in the electrical world; and they are the things this convention would want to know about if they cared about hearing anything at all on the subject from a man not in the business; so you see I have failed to get the information. I was an attorney at one time in an insanity case; and it fell to me to cross-examine the medical experts. I knew very little or nothing of the subject, and so took an opportunity of conversing with one of the medical witnesses, and learned more from him in an hour's talk than I would have done in days and days of book reading. Following this experience, had the thought occurred to me in time I would have sent for my friend Ayer. I would have had him talk to me in that charming manner of his, and in the language of the day would have come down here and "paralyzed" you. But, gentlemen, I cannot do so; I will give way to some gentleman who is clearer on the subject, whose light is more dazzling, who can, rhetorically, couch in the flowers of speech some of the beautiful things that you are doing in the electrical world.

Gentlemen, the city of St. Louis is yours, your wife's, your daughter's, and your sweetheart's, if you have any with you. (Applause.)

President Ayer then introduced Capt. Robt. McCulloch, president of the St. Louis Electric Club, who said:

Mr. President, Ladies and Gentlemen: I did not expect this of Mr. Ayer. He has followed the Mayor's directions and begun his paralyzing. I can only repeat what the Mayor has said, and that is, that the city belongs to yourselves, your wives, your daughters and your sweethearts. (Applause.)

The President then read his address, as follows:

ADDRESS OF THE PRESIDENT.

Gentlemen: At this, our sixteenth convention, it gives me much pleasure to receive you in a city which can display such an appreciation of the work in which we are engaged; to welcome you in my home and be able to present to you the attractive programme that has been prepared.

Since the first meeting in 1885 at our sister city by the lakes, we have spread upon our records evidence of the wonderful progress of the great industry which we represent, and, while as measured by time the years are few, the progress is marvelous. No art, no industry, no science can compare with it; and in no more forcible manner can it be presented than by stating that there is more capital invested in St. Louis in the application of electricity to-day than the sum total of investments throughout the United States for the production of apparatus and its use when this association was born. These are facts well known, yet hardly realized by those of us who are engaged in promoting this remarkable development. In St. Louis we have installed 266 dynamos in central stations and various private plants, supplying current to 135,000 incandescent and 5,330 arc lamps; a total of 1,800 h. p. capacity of generators, supplying 660 motors for operating almost every character of machinery, and 8,240 h. p. in generators, operating 1,126 street car motors, over 160 miles of road; and the roads under construction, to be completed within the year, will add 8,000 h. p. in capacity and 96 miles of road. This will make a total generating capacity of 30,000 h. p.

There are nearly sixty square miles of territory supplied with arc and incandescent lights, and which is crossed and recrossed with electric roads. The changing from steam and cable to electricity for motive power has transposed a bankrupt road into a most valuable property, and successful cable roads are to be changed at much expense to electric, that they may be more successful. This exposition of the development of this industry is what St. Louis has to offer for your inspection.

Since our last meeting much has transpired of interest to the members of the association. Important developments have been announced from time to time through the press, as the result of the work of inventors, and many valuable items of detail have been brought out to add to the efficiency and satisfactory working of existing apparatus. The commercial development, however, has been confined to improvements in well known apparatus and not to radical departures in the character of generators, as many were led to expect a year ago. More light will doubtless be given us in this direction through some of the papers we will be favored with; but there seems to be little likelihood of the introduction of new methods soon which will affect the quality of investments in existing apparatus, though there is reason to expect in the very near future that which will likely solve the problem of long distance transmission in a satisfactory manner. The much desired power motor for simple alternating circuits we are still anxiously looking for, and for some applications such motors as are known to be practical should be produced.

The recent patent decisions have introduced a new condition to many, brought anxiety and trouble to some and satisfaction to others. To those of us who were lulled into security by the tedious delays of the courts and the persuasive arguments of our friend, the salesman, who had so many advantages to offer, comes anxiety. To those of us who have only recently entered the field and who heard very little of claims for "foundation patents," it is a new condition we can hardly realize and we doubt its reality; and we are strengthened in our doubt by those who don't want it so. To those of us who considered carefully and believed in the ultimate establishment of the inventors' claims and rights, and who gave evidence in support of this faith by paying, in addition to a fair market price for the apparatus, an additional sum for the right to use it, and who have waited many years to receive the protection we paid for, comes the feeling of satisfaction.

That such a condition as exists to-day can be brought about calls for prompt action, that the rights of the people may be better protected. That the inventor can be so long deprived of his rights that many are led to believe by the delay that he has none, and to such an extent that millions are invested in developing a business made possible by his invention, without regard to his claims, is clear evidence of the need of reform in our laws which will provide adequate protection for the investor, as well as the inventor; and we earnestly recommend some action on the part of this association, that our properties which have been so long regarded with distrust and suspicion by the financial world may not have added to their burdens the question of their right to use devices which are vital to their success; and to so place the station manager that he must not add to his other essential qualifications that of being able to divine what the courts may do in the far future. At previous conventions this topic has been considered and efforts made to have Congress take such action as would give relief. Work in this direction should be taken up again by this body and vigorously pushed to completion.

I note with much pleasure that since our most interesting and delightful visit to Montreal most rapid advancements in electrical interests have followed, and that the Canadian Electrical Society has at a recent meeting given much evidence of remarkable growth.

That, with the greatly increased business of our electrical manufacturers, notwithstanding the protection wall over which their "heavy" products have to be lifted, indicates that our time was well spent; that there was developed a friendlier feeling and closer intimacy, besides giving an impetus to electrical development for which they seemed to have been waiting. I believe our visit has done much to hasten the time when there will be no wall between one country and one people.

The preparation for the World's Fair is rapidly nearing completion, and in a few short weeks there will be opened to the visitor one of the most magnificent achievements of modern times—an engineering and architectural wonder. In no particular is it more remarkable than in the Department of Electricity. This in its ramification permeates all departments and will make possible most marvelously beautiful effects, as well as prove the most useful of servants. Too much praise cannot be awarded those who have labored to produce this most complete exposition of the development of the science in all its forms.

The American Institute of Electrical Engineers are doing much to assist in the arrangements for a fitting meeting of the electricians of the world, and our committee will present a report which, with the information received from a representative of the World's Fair, will enable us to act in the best manner to show the national and patriotic character of our organization.

In the past year much work has been accomplished by our secretary, and the showing for the year will, I feel, be very satisfactory when his report is read. Three volumes of the association proceedings have been edited, published and delivered to members within the year, bringing this work down to date. Because of the accumulation and the large amount of matter contained in each volume this has been no small task, and the creditable results obtained in the handsome volumes, together with the thorough manner in which the office has been conducted, make it but a simple act of justice that I express my thanks and commendation at this time.

The interest in the proceedings of the convention evinced by the educational institutions throughout the country is one of the encouraging signs of the times, and justifies the statement (which is evidenced in many other ways) that the power and influence of the association are extending. The increase of membership is flattering. With this condition existing there will come up for your final consideration the question relative to the reduction of dues. While present conditions indicate that we can with safety reduce our dues, and possibly increase the membership beyond its natural growth under the present rate, yet there is much work which can be carried out to the benefit of the association which would have to be neglected if our revenue is reduced. The dues at present are hardly a burden, and a balance on the right side of the ledger is essential to the prosperity of any institution. While a change in the dues would not affect our treasury for more than a year, during which there will be extra expenses on account of the meeting which will necessarily have to be held in Chicago, I do not think it wise to reduce them at present. This question I trust will receive due consideration before action is taken.

From the beginning until to-day every producer and operator in the electrical field has had before him the serious problem of how to get men sufficiently skilled to execute in a satisfactory manner the duties assigned them. Undoubtedly this business has attracted in all departments the most ambitious elements from other lines of work, but, as we can all testify, their education in the new field has been enormously expensive to their employers. But the future outlook is promising. While within the past three years this army has more than doubled, and the new element had little or no previous training or knowledge of the work, yet there have been established more rapidly than ever clubs, societies, trade guilds and labor organizations, with the principal avowed object of self-education. Their objects and efforts in this line are to be commended, and form a pertinent topic for this body to consider. In St. Louis we have, among societies of this class, an organization known as the Electrical Exchange, composed principally of contractors whose particular business is to do the electrical construction required in all modern buildings. Their prime object in organizing was that the execution of this work might be confined to those who were responsible and maintained regular establishments. Their endeavor is to so execute the work intrusted to them that they may command the respect and confidence of the central station manager, owner, architect and builder. To this end they meet for discussing improved methods, and such other matter as may be suggested and calculated to be of mutual benefit. Insurance inspectors, supply houses and central station companies are eligible to membership. In contact with them we find them ever ready to co-operate with us in any movement to improve the service and increase the satisfaction of our customers; and since their organization a much better feeling has been established and the quality of work greatly improved.

Within the past year has been organized the National Association of Electrical Workers, with headquarters in this city, and having branches in many towns and cities. This organization is largely composed of linemen, though it expects to embrace in its membership electrical artisans or workers in every department. Their principal object is, as stated in the first number of their journal, to band themselves together for mutual education and improvement, to establish rooms and provide instructors, and adopt such other methods as may improve the standard of electrical labor. This organization is capable of accomplishing a vast amount of good, if maintained on the high plane outlined. If the effort is earnest and honest, we can all lend them a helping hand and will do it gladly. The wage question will never be an element to make a breach when the rank and file of electrical workers have mastered their business. But until that time arrives those who are among them as leaders should keep in mind that satisfactory work performed in a conscientious manner is the first essential to pleasant mutual relations between the employer and the employed, as well as the strongest lever to raise wages that can be produced. Thoughtful care on the part of the manager must be given that the man who climbs the pole to clear a ground or close a circuit, in the sleet and rain, and all others as well, be protected by all safeguards in the way of instruction and appliances that can be suggested. The engineer, the dynamo tender, the lamp trimmer, all must be encouraged in their efforts to improve in knowledge, by active co-operation on the part of the management. A close acquaintance with our employees is an essential to a full appreciation of their services. Many acts of real heroism are performed by the lineman or the dynamo tender, only that the service may not be interrupted, and that many times without a passing comment. We can shake out the crosses and clear the grounds by a closer acquaintance with our men and their work.

We have for consideration a splendid list of papers which is varied and yet devoted to topics which I trust and believe will develop that interest which will bring members to their feet in thoughtful discussion. The discussion of the papers and such topics as may come before you I trust will receive the usual dignified treatment and earnest interest which has always obtained in this body.

During the year that has passed death has claimed an unusual number whose names have been prominently identified with the active promotion, development and application of electricity in its various branches. Those particularly interested in the department devoted to telegraphy were, Cyrus W. Field, Wilson G. Hunt, F. M. Gisborne, Jay Gould and Norvin Green; in electric lighting and railways, C. J. Van Depoele, E. T. Lynch, Jr., M. M. Slattery, and in Europe, Werner Von Siemens. In this list are the names of those who have borne much of the heat and burden of the day and were among the few pioneers who hewed the path and assisted to broaden the road, by overcoming difficulties which we, who find it so comparatively smooth to-day, little appreciate.

To our guests who have assembled with us and honored us by their presence, and who will further honor and instruct us with their words of wisdom, I want to express our thanks; and I trust that the members will

by their presence at the different sessions demonstrate the sincerity of this expression on their behalf.

At the conclusion of his address the president declared the sixteenth convention of the National Electric Light Association formally opened.

The president announced the burning of one of the largest stations, under the management of ex-President Huntley, at Buffalo, and read the following telegram:

"I regret my inability to be present. You have my best wishes for a successful convention.

"C. R. HUNTLEY."

The paper by Mr. A. D. Adams on "Wrought Versus Cast Iron for Field Magnet Frames" was then read.

There being no discussion on this paper, the secretary made several announcements.

Letters of regret were read from Prof. Henry T. Bovey, Montreal, Canada, and Prof. Ed. L. Nichols, Ithaca, N. Y.

Letters of invitation to participate in courtesies were read from the Merchants' Exchange, the Bell Telephone Company, the Pastime Athletic Club, and the Knapp-Sellner Chandelier Company, of St. Louis.

An invitation to hold the next meeting of the association in Omaha, Neb., was read from Hon. G. P. Bemis, Mayor of Omaha. On motion of Judge Armstrong the latter was referred to the proper committee and the former were accepted with the thanks of the association.

The president stated that the Knapp-Sellner Chandelier Company would make quite a display of fixtures, and it was desired that as many of the delegates as possible would avail themselves of the invitation. Also that there would be open house at the Electric Club at all times of the day and night, where a buffet lunch would be served and all in attendance at the convention might resort at any time.

The president read the programme of entertainment provided by the local committee, a copy of which will be found elsewhere in this issue.

Judge Armstrong then read the report of the Committee on the World's Columbian Fair, the chairman, B. E. Sunny, not being present:

REPORT OF THE WORLD'S COLUMBIAN EXPOSITION COMMITTEE.

Gentlemen: The Paris Exposition of 1881 was lighted in part by 1,383 arc lights, and was the first arc-lighted exposition. The Louisville Exposition, of 1882, was lighted by 5,000 incandescent lights of 16 c. p. each, and was the first use of incandescents for exposition lighting. The New Orleans Exposition was lighted by both arc and incandescent.

The Paris Exposition of 1889 made the largest use of electricity up to that time. There were for public lighting service 1,003 arcs and 8,837 incandescents.

For private lighting there were used 623 arcs and 4,010 incandescents. The total of the service installation aggregated 5,125 h. p. capacity, and with small installations the grand aggregate capacity reached nearly 4,000 h. p. There was practically no use made of electricity as a motive power.

The World's Columbian Exposition has placed contracts for 4,500 arc lights of 2,000 nominal candle power each, and received donations from miscellaneous exhibitors of about 700 additional. They have placed contracts for about 80,000 incandescent lights, and received donations as special exhibits of about 10,000 additional. They have placed contracts for 2,900 h. p. capacity of power generators, and received donations of 1,600 h. p. capacity.

They have made contracts for electrical fountains requiring an installation of 900 h. p. capacity. The aggregate of power generators and fountain plant (the latter will be used particularly for charging the storage batteries of the electric launchse) is 5,300 h. p.

The total aggregate of the electrical installation, therefore, amounts to 19,500 h. p. The total aggregate of boiler capacity employed is 18,000 h. p. on the standard rating of 30 pounds of steam per horse power. With such efficiency as should be expected from the engines installed, this represents an effective total of 24,000 h. p.

The most interesting point of this plant will be the use of oil as a fuel. From the time the crude petroleum is emptied from the railroad tank cars into the World's Fair storage tanks, at the extreme southeast corner of the grounds, this oil becomes part of the power plant, the pressure upon the delivery pipe being automatically controlled by the steam pressure in the boilers. Delivery to boilers is made by pipes laid underground from the storage tanks to the boiler house, and the oil introduced into the furnace through an atomized jet.

A point of exceeding interest in the engine and dynamo room will be the very large adaptation of dynamos to Corliss and medium speed types of engines in direct connected combinations. The largest of these will be a set of vertical triple expansion engines with two connected armatures. At 160 pounds steam pressure this single unit will give most economically 12,000 h. p., with a capacity for continued service of 1,500 h. p. output.

Next to the universal distribution of electric power for all points of the grounds, the most marked advance of the time is the application of electricity to the transportation service of the Exposition. This service will be by a three-mile double track elevated railroad, following all the precedents and best practices in block signaling systems, power brakes and all other safeguards of the modern steam railroad used in exclusively passenger traffic. The entire operation will be, however, by electric power, drawn from an independent power plant of more than the aggregate capacity installed at the Paris Exposition. In this power house will be found the latest examples of the large range of direct driven power generators, five in number and aggregating 3,500 h. p. capacity.

To those who have not had an opportunity of informing themselves of the part that electricity is expected to play at the Exposition, these figures will be interesting and will indicate to all how much greater by comparison with preceding expositions the Columbian Exposition is bound to be.

The sensational reports telegraphed from New York that many of the prominent electrical firms in that State had decided to abandon the space allotted to them and make no exhibit, were found on inquiry to be based on the fact that three small concerns had gone out for reasons that were personal to them. Every foot of space in the great building has been taken and every electrical concern of any consequence in the world will be fully represented.

The active work of preparing for the exhibits has been going forward for some weeks and many of the electrical firms have made substantial progress in the erection of the booths.

The intellectual programme, under the auspices of the World's Columbian Auxiliary, promises to be of remarkable interest. As you know, Prof. Elisha Gray is at the head of the electrical branch, and he now has assurance that the gathering of electricians from all parts of the world will be a grand one. Respectfully submitted,

B. E. SUNNY, Chairman.

At the conclusion of the reading of the foregoing report the meeting adjourned until 2 o'clock.

The president called the meeting to order at 2.30 o'clock. The first business of the session was the reading of the paper on "Relation of Insurance to Electric Light and Power," by Mr. William Brophy.

After a discussion of this paper at considerable length, Mr. R. H. Sterling's paper on "Some Exeperiences with the Alternating System," was read.

President Ayer called the convention to order at 10:30 on Wednesday morning, and announced the first business to be the paper by Prof. George Forbes, of England, on "Thermal Storage for Central Stations."

After the discussion of this paper the convention adjourned until 2 o'clock p. m.

When it re-assembled, Mr. Charles S. Bradley, of Fort Wayne, Ind., read his paper upon the subject of "Long Distance Transmission of Power."

The President: We have three papers on this particular subject, one by Mr. Bradley, one by Dr. Louis Bell and one by L. B. Stillwell. The subject is treated by the three gentlemen from three different standpoints. The subject will most profitably be discussed after listening to all of them. The next paper on the programme is that by Dr. Bell, which is in order.

The paper entitled "Power Transmission for Central Stations," by Dr. Louis Bell, was read by Dr. Bell.

Mr. L. B. Stillwell, of Pittsburgh, then read his paper "Under What Conditions Is the Use of Water Power Economical?"

On Thursday the convention was called to order at 10 a. m. by the president, who announced that the first order of business of the day would be the reading of a paper by Mr. W. H. Browne, of New York, upon "Underground Conduits and Conductors." Mr. Browne not being present, Mr. Wm. J. Hammer, in response to the request of the president, then advanced to the platform and read to the convention Mr. W. H. Browne's paper, entitled "Underground Conduits and Conductors, and the Experiences of the Electric Lighting Companies of New York City."

The paper on "The Incandescent Lamp from a Commercial Standpoint" was at this time read by its author, Mr. Calvert Townley.

In the afternoon Judge Armstrong called the meeting to order. The first business was the reading of the paper of Mr. C. H. Meyers on "The Vuleanizing Process for the Preservation and Strengthening of Poles, Cross Arms, Ties, etc.," which was followed by the paper of Judge Armstrong, on the "Morals of Corporations."

The discussion on the paper of Mr. Calvert Townley, on "The Incandescent Lamp from a Commercial Standpoint," which was read at the morning session, was then taken up.

Mr. Armstrong offered resolutions of thanks to the citizens of St. Louis, the Electric Club, the Electrical Exchange, the Bell Telephone Company, the city press and to the president, Mr. James I. Ayer.

In the executive session the secretary's report was read, which showed the association to be in a most healthy financial condition. There were thirty-one new active members gained during the year; and the total membership of all classes is now 250.

Nikola Tesla and James I. Ayer were elected as honorary members of the association.

A hearty invitation was given to the association by Dr. E. C. Kilbourne, of Seattle, Wash., for the association to meet there next year.

The following gentlemen were elected officers of the association for the ensuing year:

President, E. A. Armstrong, Camden, N. J.; First Vice-President, M. J. Francisco, Rutland, Vt.; Second Vice-President, C. H. Wilmerding, Chicago, Ill.; Secretary, George F. Porter, New York; members of the Executive Committee; J. A. Seely, New York; E. F. Peck, Brooklyn; A. J. De Camp, Philadelphia; W. A. Morrison, Woodstock, Can.; H. J. Smith, New York; C. H. Blaxter, Pittsburgh; H. H. Fairbanks, Worcester, Mass.; Frederic Nichols, Toronto, Ont.; A. M. Young, Waterbury, Conn.

The place for holding the next meeting was referred to the Executive Committee, and the convention adjourned.

The convention papers follow in the order in which they were read, and are given in full.

Wrought versus Cast Iron for Field Magnet Frames.

BY A. D. ADAMS.

The modern bi-polar dynamo may be broadly divided into two essential parts, the field magnet and the armature.

The office of this armature is to conduct magnetism through its core, and cut or cross this magnetism by means of its windings or inductors.

The office of the field magnet is to conduct magnetism from one side of the armature to the other, and, usually, to carry the field coils.

It is entirely possible to draw a current from an armature, when revolved within an exciting coil, even though it have no field magnet to complete the magnetic circuit.

One objection to such an arrangement would be the excessive amounts of copper and energy required in the exciting coil for a given effect, as the lines of magnetism would have to pass through the air in order to complete the magnetic circuit from one side of the armature to the other.

The great advantage of the combination of the armature and field magnet over the above arrangement lies in the fact that the field magnet forms a magnetic path of much less resistance than the air.

The same reasoning that leads to the completion of the magnetic circuit through the field magnet seems to indicate that the best metal for this purpose is that having the greatest magnetic capacity and permeability per unit of area and cost.

The aim in this paper is to point out some of the advantages of wrought iron over cast iron for the field magnet frames of bi-polar dynamos.

The researches of Prof. Ewing and Dr. Hopkinson show that the same magnetizing force per unit of length, as measured in ampere turns, which produces in good hammered scrap iron a magnetization of 100,000 lines per square inch, produces in good gray cast iron only about 42,000 lines per square inch, and these values are about as high as we can go in either of these metals and get anything like a proportionate increase in magnetism for increase in magnetizing force.

If, then, the same number of ampere turns are to be used for a given length of magnetic circuit, cast iron must be about two and a half times the section of wrought iron.

Since the field magnet, to have the same magnetic carrying capacity at the same permeability, must have about two and a half times the section when made of cast as when made of wrought iron, the weight of cast iron for the same type and capacity of machine will be about two and a half times that of wrought.

In order to compare the relative amounts of copper required in field magnet windings for machines of the same capacity, but with different metals in the field magnet, the same wattage or exciting current must be assumed for all types.

Take two machines of the same type and capacity, with the same length and section of air gap between the armature core and pole pieces, and let one field magnet be made of wrought and the other of cast iron, throughout, each having the field magnet core circular in section and the area of the cast iron core two and one-half times that of wrought.

Since the ampere turns required on each magnet are equal, also the watts expended in winding, there will be the same number of turns of wire on the cast iron as on the wrought iron field.

As the two field cores are circular in section and one two and a half times the area of the other, the length of wire required around the cast iron will be to that around the wrought iron core as

$$\sqrt{2\tfrac{1}{2}} : 1.$$

Since the weight of copper required to transmit a given amount of electric energy at a given pressure and loss varies as the square of the distance, the weight of copper on the cast iron will be to the weight of copper on the wrought iron core as

$$\left(\sqrt{2\tfrac{1}{2}}\right)^2 : 1^2 = 2\tfrac{1}{2} : 1.$$

The general practice among American manufacturers of bi-polar dynamos and motors is to use either cast iron entirely or cast iron yokes and pole pieces and wrought iron cores.

In the latter case the sections of the cast iron parts are usually made only about one and a half times that of the wrought iron.

With these proportions between the wrought and cast iron either an excessive amount of magnetizing force must be expended to drive the magnetism through the pole pieces and yokes, or else the wrought iron core must be only saturated to a very low degree.

The amount of copper or field current must be, in either case, considerably increased above that required when the cast and wrought iron parts have their correct relative proportions.

Magnetic leakage is considerably increased by the use of cast iron, as compared with wrought iron, by reason of the greater surface of the cast iron, also the much higher relative degree of saturation at which it is frequently used.

It is evident from the above that the weight of iron and copper for the field magnet and winding in a machine of given capacity are both more than twice as great when cast as when wrought iron is used entirely.

When the field magnet is made partly of cast and partly of wrought iron, the increase of iron and copper is not so great, and varies with the relative section of the cast and wrought iron parts.

The advantages of wrought iron over cast for the field magnets of bi-polar dynamos seem to be more generally appreciated in England than with us, as nearly all the leading makers of such machines there use forged wrought iron entirely for field magnet frames.

As the relative magnetic value of wrought and cast iron becomes more generally appreciated by dynamo builders in this country the former will, no doubt, be much more generally adopted.

The following data of a 2-h. p., 110-volt motor, designed by the writer, and having a forged wrought iron field magnet throughout, may be of interest as illustrating some of the above points:

Type of motor, bi-polar.
Type of armature, smooth core, Gramme.
Weight of motor, 250 pounds.
Speed of armature without load, 1,700 revolutions per minute.
Turns of wire on the armature, 360.
Size of wire on the armature, No. 15 B. & S. gauge.
Weight of armature wire, 3.7 pounds.

Resistance of armature, cold, .32 ohm.
Resistance of field coil, cold, 140 ohms.
Current in field coil, .78 ampere.
Wire in field coil, 26 pounds, No. 21 B. & S. gauge.

Particular attention is called to the number of indicators on the armature of this machine, namely, 360, which is very small when its weight and the moderate speed at which it runs are taken into consideration.

It is very evident that these results could not have been obtained had cast iron been used, either wholly or in part, for the field magnet.

It may be pointed out that the weight of wire and the energy required for field excitation might have been considerably reduced had it been thought best to reduce the length of the air gap, but it was desired that the field exciting force should practically overcome the tendency of the armature to distort the magnetic field in the air gap, which result has been obtained by the above construction, so that no change of lead, with the brushes, is necessary when the load of the motor is varied from nothing to its full capacity.

Relation of Insurance to Electric Lighting and Power.

BY CAPT. WM. BROPHY.

This subject has been treated so often and by so many able men that I have grave doubts as to my ability to add anything to what has already been written and said that will be of interest to you.

It has been my good fortune to be in a position to witness the early attempts to introduce the electric light, and the attitude of the insurance companies and their agents, as well as State and local boards.

To say that they receive this new form of illuminant with unmistakable manifestations of welcome would not be in exact accordance with the truth. Those who were disposed to give it even a half-hearted welcome were very few, while those who receive it as another element of destruction of property and insurance dividends were largely in the majority.

To say that they were entirely unjustified in their lack of cordiality for this new application of electrical energy, that was destined to reverse the regular order of things as they have existed since the creation, by turning night into day and rendering us independent of the silvery but uncertain rays of that shining example of reflected brilliancy, the moon, would be far from true.

The average citizen, upon witnessing for the first time the brilliant arc as it leaps from point to point of the carbons, would not divest his mind of the feeling that this mysterious force was attended with more or less hidden danger. He naturally reasoned that if it could produce this most brilliant light, and heat enough to melt the most refractory substances, it might easily get beyond human control and start incipient conflagrations simultaneously at numerous points in its path, that might destroy not only individual blocks, but wipe out entire towns and cities.

To say that this feeling of distrust of this new form of illumination did not take deep root in the minds of the fire insurance fraternity would be to claim that they were out of place on this planet of ours, and should not be classed with ordinary members of the human race. They are not and do not claim to be other than ordinary mortals, and should receive the same indulgence that others receive from you whose fears have led them to oppose the introduction or extension of the electric lighting systems.

Those engaged in the insurance business and those engaged in the manufacture and sale of electric lighting apparatus, as well as those who furnish electric light and power, have one common end in view, viz., to secure at least a fair return on the capital invested in their business and for their own time and labor. Each of these interests needs the help of the other, and there is no good reason why one should antagonize the other. That this has been done in the past I will not deny, but to say that the insurance companies were wholly to blame for their hostility to the introduction of the electric light would be manifestly unfair, to say the least.

Insurance companies have paid dearly in the past for the mistakes of those engaged in the introduction of all modern forms of artificial illumination and many forms of heating, a few of which I will here enumerate.

Since the days of the tallow candle and whale oil lamp we have had gas, camphene, burning fluid (rightly named), kerosene, refined petroleum and its products—naphtha and gasoline—some of which have caused enormous losses by fire to the owners of property and insurance companies, and the loss of thousands of human lives.

Camphene and burning fluid were, in due course of time, displaced by kerosene oil, which was produced by the destructive distillation of coal. This in turn gave way to petroleum and its products—naphtha and gasoline—which still hold the field, furnishing a cheap and fairly good light, increasing the number of fires and causing heavy losses annually to insurance companies. To such an alarming extent did these losses grow after the introduction of the products of petroleum for the purpose of illumination that legislative action had to be invoked to regulate the manufacture, storage and sale, and establish a standard of safety therefor.

After these costly experiments, was it to be wondered that the insurance interests should view with mistrust this new and mysterious force, electricity, when the attempt was first made to work it in harness to furnish light?

It may be said that they should have familiarized themselves with the new element and learned how to keep it under control. The answer to that might be, To whom were they to apply for such information? Those in the electric lighting business were not overburdened with a knowledge of this subtle force, and they, being but human, could not be expected to admit, if they believed it, that it would increase the fire hazard at all, for such an admission would arouse the antagonism of the insurance companies and prevent the growth of their business. With the crude methods at first employed for the transmission of the electric current from dynamo to lamps and circuits, fires of more or less magnitude were quite frequent, with consequent loss to the insurance companies. These unfortunate happenings did not tend to cause them to look upon this new candidate with unqualified favor. On the contrary, many were inclined to look on buildings equipped with electric lights as worthy of a place on the "prohibited list," while others viewed them as extra-hazardous and not to be eagerly sought for by local or special agents, even at a very high rate of premium.

But in spite of the evident hostility of this powerful combination, the electric light made slow but steady progress in the good graces of the public, and, while looked upon as being capable of doing more than its share to reduce dividends on insurance stocks, yet it has gained somewhat in favor with them.

How to deal with this new, and, to most people's minds, dangerous element was a most serious question with the underwriters of this country. To many it seemed best to increase rates all along the line where is was introduced, and thus prevent or discourage its use. Had such action been taken there is no doubt but it would have had the effect of retarding the growth of the electric lighting business very greatly indeed. Fortunately, this last expedient was resorted to in only a small portion of this country.

In that little corner of our great and glorious country known as New England the insurance organization known as the New England Insurance Exchange was most fortunate in its selection of a chairman for its then new committee on electric lighting. He found time while performing his regular duties as a special agent to post himself in the mysteries of dynamo electricity, and as his knowledge increased his friendship for this form of illumination and those engaged in producing it increased in like proportion.

The task of determining the best course for the underwriters to pursue toward it was no easy one for those who undertook it. Fortunately, they were conscious of their own inexperience and inability to give instructions until they had devoted a sufficient time in observation and study of the subject. This information was accepted, not only from the most eminent men, but from those occupying the most humble position in the business.

In this way the inspector, instead of assuming a knowledge which he did not possess, for the sake of increasing his own importance in the eyes of those who employed him, kept in touch with those whose daily experience enabled them to detect any inherent weakness in the devices and systems of transmission, and enabled him to assist in perfecting the same by advocating all improvements that increased the safety and did not impair the efficiency of the system. In this way the standard of safety has been raised to a degree that approaches perfection.

In this way fire losses caused by electric currents decreased, notwithstanding the enormous increase of electric light, power and railway business, and the fears of the insurance companies were in a great measure allayed. In marked contrast with this mode of procedure is that of certain insurance inspectors and others who are now engaged in an attempt to undo all that has been done to bring about an era of good feeling between these two great interests and enable them to work together harmoniously.

This attempt at mischief making is all the more reprehensible, owing to the progress that has been made toward harmonious relations at a meeting of your representatives and those high in the councils of insurance associations. With the exception of one or two of those present at that meeting, all expressed themselves in the most friendly terms toward those engaged in the electric business, and desired to cultivate a feeling of friendship.

To those inspectors who are engaged in an attempt to throw discredit on those engaged in the electric business, by practically saying "You are not to be trusted," I will say, beware, the electric industry is not the puny infant it was some ten years ago. Millions are now invested in it, while the phenomenal growth of the electric railway challenges the admiration of all, and it is fast attaining the vast proportions of the electric lighting industry. These joint industries will submit good-naturedly to all reasonable requirements exacted by your employers, but they cannot be expected to submit to continual annoyance or admit that they are unable to conduct their own business much longer by those who seek to do so by might and without a shadow of right. The electric light business can exist without the fostering care of these self-appointed guardians, who seek to magnify their own importance by throwing discredit on this association. Because they are tolerated, they must not seek to dictate, as there is a point beyond which forbearance ceases to be a virture with all classes, and electric lighting companies do not differ materially from the rest of the human family in this respect.

Having given you a little of the early history of the combined efforts of those who sought to make the electric light safe in its early days, and pictured some of the obstacles that had to be met and overcome, I will try to point out the best methods to pursue to stop the silly twaddle about the dangers of electric lighting by professional agitators, sensational newspapers and timid old ladies of the male persuasion, and deprive the smart (?) insurance man, who insists that there are hidden dangers contained in every portion of the plant, that compel him to charge an increased rate of premium for its production and use, of his stock in trade.

The published opinions of some of these gentlemen who do business in that smart little city sometimes known as the "Hub of the Universe," that has suffered quite recently from an unusual number of very large fires, as to the part that electricity has played in causing the same would polarize a dynamo and paralyze its owner.

A few choice quotations are here appended:

"The Remick fire was caused by electricity." "I think there is an epidemic of fires, as in 1872, and insurance companies must yield gracefully to the inevitable. Still, it is obvious that they must have more money, and that those trolley wires must come down." "Many who were not willing to be quoted assigned the electric wires as the cause of much of the fire loss, and claim to see a connection between the growth of the fire loss and the growth of the use of electricity in the same district."

The men mentioned in the last paragraph are to be commended for their modesty in not wishing to have their names handed down to posterity as the wise (?) men of the "modern Athens."

In the city of Boston, mind you, the Board of Underwriters have for a number of years maintained a system of electric light inspection, paid for by assessments levied on electric lighting companies, also on firms and individuals engaged in electric construction. The city is compelled by State law to maintain a similar system of inspection. In addition to this, one of the electric lighting companies, whose officers are not possessed of an abiding faith in either of the above named systems of inspections, makes it a point to inspect all wiring before they will connect thereto.

Yet with all these safeguards and checks on those engaged in electric lighting and construction, those men "claim to see a connection between the growth of the fire loss and the growth of the use of electricity."

The real fact in the case is that millions of insurance has been placed by the agents and brokers on property that is far more hazardous than the very poorest electric light plant in the business portion of the city in question; ordinary prudence having been thrown to the winds in writing such insurance. The inevitable consequences of such folly ensue, viz., disastrous fires. The agent who sees a possible loss of commissions hastens to give a plausible excuse to his companies, by charging the origin of the fires to electricity and demands an investigation of the fire department for not extinguishing them before they were kindled, concealing the fact that his own methods of placing insurance encourage incendiarism and promote carelessness.

In view of the fact that it is now proposed to add a small charge to the rate of insurance where electric lights "are installed in compliance with board rules and specifications," and a charge of 25 cents where they do not meet with the approval of the insurance inspector, I would advise you to pursue the following course:

Where a company does its own wiring for its customers, proceed with as much care as though the building in which you are installing wires and fixtures was your own, and you had no insurance on it. Where the work is done by others, inspect every foot of wire, every joint, cut-out, switch and insulator, and on no account turn on current until you are satisfied that it is as safe as it is possible to make it. Do not rely on the uncertain movements of the insurance inspector or any other system of inspection that too often fails to inspect. You are the one whose business will suffer from the bad effects of fires caused by defective wiring.

We now come to the electric light station. Do not rent one end or the basement of a flour, saw or planing mill, and place your machinery in it and expect to get any better than the rates charged on the buildings named above. While they are considered extra hazardous risks, insurance boards in their wisdom (?) will tell you that the introduction of electric light machinery increases the hazard and also the rate. This statement may cause you to smile, but there are those whose early experience have found it no laughing matter.

Do not place it in some old abandoned building, for, as in the above case, an increase of rates will follow. Do not set your machinery down on the ground and build a tinder box around it, for besides assuring high rates of insurance it does not speak well for the business sagacity of the owner.

Proceed as though you proposed to do a legitimate business and for all time. Build your station on solid foundation, the walls of brick or stone, not over two stories high—better only one—solid brick or stone foundations for engines, boilers, dynamos and pumps; a solid brick wall extending three feet above roof between boiler and engine room; the floor of boiler room of brick, stone or cement; if building is two stories high, have the boiler room the same, having clear, open space between floor and roof; floors of engine room, if dynamos are not placed therein, can be of iron or stone; if dynamos and other apparatus are in the same room, floor should be of three inch plank, tongued and grooved, with hard wood floor of one inch boards, matched and laid at right angles to, or diagonally on, the plank, the whole laid on heavy square timbers or iron I beams; the roof should be of three inch plank, splined and grooved, resting on square, hard wood timbers or trusses or iron I beams; cover this with slate, tin or gravel, according to pitch; leave the walls bare; do not attempt to improve their looks by covering them with wood and creating concealed spaces; roof and ceiling, ditto; inclose stairways with plank, and provide self-closing doors therefor; cover the doors in brick partition walls with tin; also the frames; do not build a wooden hen-coop or Turkish pagoda on top of roof, and call it a wire tower; build from floor of dynamo room, of brick or tile, a good substantial tower, of ample size for all wires; put them in systematically and not by guess; make switchboard of good, hard, well seasoned wood, skeleton in form, or use the sides of brick or tile tower; if slate switchboard is used, bush all holes through which wires, plugs or other connections carrying high potential currents pass with glass porcelain or hard rubber; do the same if sides of brick wire tower are used; use this same material where wires pass through floors or other woodwork; secure a supply of water for protection against fire from town or city mains, if available and pressure is sufficient. In doing this have pipe leading into station of ample size. It costs no more to excavate for a six inch pipe than it does for a one inch, and the difference in cost of pipe is not enough to outweigh the value of an abundant water supply in case of fire, for, like the Texan's revolver, then is the time when you want it and want it bad. If water cannot be secured in this way, make your boiler pumps sufficiently large to throw, when connected together, or working singly, from three to five hundred gallons per minute, according to circumstances. Remember that all electric apparatus, including dynamos, is very susceptible to damage by fire or water, and by reducing the amount of combustible material in your plant you reduce the possibilities of a large fire and the necessity for a large amount of water.

Do not, if possible, build your station adjoining or too close to such risks as oil refineries, planing, saw and flour mills, grain elevators, etc. If obliged to do so, have no, or as few, openings as possible in the exposed side or end, and provide metal covered shutters for these few. Run all your wires in plain sight, leaving ample space between them.

In planning your station, allow for future growth and enlargement, without disturbing the present arrangement of machinery, etc. Store your oil, and, if possible, your other supplies, outside the station, and if you have a repair shop, do not have it in the second story, attic or basement. It is much better outside the building. If you must have it in the building, do not box it up out of sight, but separate it, if you must, by an open partition or fence from the rest of the building.

Divest your own mind of the idea that dirt, grease and

slush must be the wedded partner of an electric light station, and impress on that of your employees that an absolute divorce must be granted if the marriage ceremony has been performed. "Cleanliness is next to Godliness," but nowhere does this maxim apply with such force as in an electric light station.

Having finished your plant in accordance with the foregoing requirements, you need have no fears of acts of unneighborly conduct or apparent neglect of your property by the ever active insurance agents. Instead of waiting for you to seek them out and beseech them to insure it, they will be as attentive to you as the most ardent young suitor ever was to his lady-love. Remember that so-called tariff rates and agreements, that hold insurance associations together for the purpose of maintaining high rates, are but ropes of sand, and that keen weapon—active and oftentimes bitter—competition, is continually cutting it up in little pieces and letting this craft, that should be rightly named "Trust," drift on the hostile shore of independent action.

DISCUSSION.

The President: You have listened to a paper from one that many of us have learned to respect and value as one of the most active agents in developing the electric lighting business, in the way of restoring to the public confidence in the harmlessness of our wires and to give them faith in the continuity in the service. Primarily, his interests were for the insurance people; but his close relations to the central station men formed in looking after the insurance interests made him a strong advocate and a strong supporter of the development of electric lighting. His work was done at a critical time. His paper is of such a character, emanating from the insurance standpoint, that it cannot fail to be of great value to the interests represented in this association.

Mr. Hammer: It seems to me, in view of Mr. Brophy's remarks, that it is possible a closer union could be established between the National Board of Fire Underwriters' Association and the men who are actively engaged in the electric light enterprises, by having a joint committee, composed of members of the National Board of Fire Underwriters' Association and of the National Electric Light Association, come together and compare notes and have a report issued which would be a joint report. From what the Chairman of the Board of Fire Underwriters told me, there is a feeling of considerable jealousy on the part of that board as regards the report issued by the National Electric Light Association. They feel that they should not be dictated to by this association, and, naturally enough, we feel that we should not be dictated to by them.

Mr. Brophy: I have no objection to any rules that may be made by the Board of Fire Underwriters, so long as they do not exact undue concessions or place undue restrictions on the business. I have lately come into possession of certain rules issued by the National Insurance Board, as they style themselves. I have lately received them. They vary but slightly from the rules issued by this association; and I really recognize my own work in them. I suggest that our standing Committee on Safe Wiring before the next meeting compare these two rules, and, if possible, work in harmony with the insurance companies. There is no reason why there should be any antagonism between the two. It is certainly as much to the interest of the members of this association to reduce the fire hazard from electric lighting as it is for them. I think there is no doubt that you are willing to do it; there is no occasion for having two sets of rules, or having any misunderstanding about them.

Mr. Francisco: I have been an insurance adjuster for about twenty-five years, and know something about the knowledge which most of the insurance agents have about the electric lighting business. Nine-tenths of them do not pretend to know anything about the electrical part of the business. There are a few insurance men that understand it. There are a great many things we ought to take into consideration. There are points in these rules that certainly should be amended. If the electric light men will taken up this matter and push it to protect their own interests, they can reduce rates to a minimum and get good insurance. The high rates are the result of the haphazard, loose way of construction and arrangement which prevails in many places. We find all kinds of poor and ill-advised construction. I would never place my dynamos on a flooring of timber. I would have a stone or brick floor laid in cement and place my dynamos on that. Captain Brophy says your wire should be above the floor and below the ceiling. I can stand in one position in my station and see every wire in the station.

Mr. A. J. De Camp, of Philadelphia: This question of insurance is one that is frequently before us. So far as adopting a uniform set of rules is concerned, we seem no nearer a solution of the matter than when the question was first taken up. This, nevertheless, is a subject of great importance. It may be impossible to adopt a rigid set of rules and make them apply to all stations alike. A rule that could be applied to the station which Mr. Francisco has just described might not be applicable to a station at another point. I think the rules adopted at the Montreal convention were good rules—there is no question about it; but we should have rules which would not operate unjustly in some cases, as any set of rules rigidly adhered to are sure to do. It has therefore occurred to me that it might be a good plan, instead of having this committee meet to consider and adopt these rules, to have it resolve itself into an arbitrating committee. If the committee is made up of men acceptable to both parties, we are sure to get better results. That strikes me as being a good way to get at the matter. So long as you have a great bulk of the wiring done under competition, by people outside of the lighting business and insurance companies, who are seeking business, and who sometimes take contracts below the price at which they ought to take them, you are certainly taking risks of bad work. I contend that the class of contractors would be more careful in the matter of their contracts if they knew that the work was subject to inspection by a committee alike recognized by the lighting companies and the insurance companies; and we would get better work. If my ideas on this subject are correct, then the most serious difficulty that confronts us is in getting a set of arbitrators who will possess the confidence of both parties.

Mr. Issertel: I would like to ask why these rules are not universally accepted. I find in certain cities of the same State, that in one city a certain set of rules, and in another city, especially in Pennsylvania, another set, entirely different, are carried out. For instance, in Philadelphia certain switches are allowed by the insurance inspectors, while in Pittsburgh they are not; and in little matters of detail differences exist in many places. I find that many central station men are so disgusted with the way these rules are being handled that they give them very little attention; one man told me that he does not follow the rules, but uses his own judgment. I would like to know which set of rules is standard.

Captain Brophy: Of course it takes a good while to overcome local pride and prejudices. It seemed to be the proper thing to take a set of good rules and change them, so that they would be considered a local production; and in this way much of the variation came about. The meeting was called at Cape May in order to get a uniform set of rules that would be in force from Maine to Texas. I do not think they have yet been promulgated.

Mr. Armstrong: The underwriters are the ones who should make the rules. They are the particular ones who insure the properties. While it is true that we, as electric light managers, are equally interested with them, because by that craft we have our livelihood, still we must recognize the fact that they are the ones who have to run the risk and bear the loss when it comes. Mr. De Camp's idea of having a committee of arbitration is a good one; let the thing be done. It is an excellent plan; the only question is, Will it work? I do not think we need give our committee any instructions on this subject. It will be the business of this committee to look out for these rules when they come from the underwriters, and if there is anything that needs correction they will see that it is done. If they are less stringent than the rules we have adopted, then we are surely on the safe side; if they are more stringent, unnecessarily harsh, then the committee can see that they are modified. If they are more stringent, and still in the right direction, our rules should be made to conform to them.

Mr. De Camp: I should like to ask if any set of rigid rules would be susceptible of being carried out to the letter—whether some discretion has not to be left to somebody; in other words, notwithstanding all the careful consideration given to the subject, based upon long experience, is it not quite possible that an occasion might arise where it would be advisable to deviate from the rules—a deviation which might in the particular case improve upon the rules themselves, but which deviation probably would be dangerous to establish? That would be a case, I should say, where an arbitrating committee might exercise its powers.

Mr. Brophy: I have had a large experience formulating rules; and it is my judgment that a rule was never yet made that would not be deviated from. There must be some discretion left to the constructor, to the man who is furnishing light, or to the insurance inspector. For this very reason, our committee is a standing committee, so that we can at any time add to or change or modify these rules whenever it becomes necessary.

Some Experiences with the Alternating System.

BY R. H. STERLING.

In choosing the above title for my paper, I feel that I have taken one that we are all more or less interested in, and especially those who are directly identified in this inductive method of furnishing light, and whose work in the practical details of this system has been accompanied with interesting experiences, which are always beneficial to all of us in perfecting our profession.

To those who adopted the alternating system in the early days, I need not recall the feelings with which we looked on this long-distance transmission of energy for incandescent lighting. It was such a gigantic stride—such a radical departure from previous methods of incandescent lighting—that many who had experimented for the benefit of parent companies before were a little cautious about nursing this new infant up to the state of practical manhood. Especially were we so when so much was said and written by the opposition side and by others who claimed to be non-partisan. However, our company, among the first, did install a large alternating plant—the largest, I believe, at the time in the United States. How wise we were in doing so, I will answer by pointing to the enormous growth and success from the start of alternating current lighting, and its finally being fostered by those who were at first its bitterest enemies.

We did experiment some, I will admit. A few minor details in apparatus did not just meet the requirements for practical use; but our parent company has always been willing to adopt the suggestions of its users and remedy defects discovered by them—a plan, by the way, which should be followed by all who manufacture apparatus—for the central station men are those who are best able to judge its merits and criticise it from all sides.

I will now take the principal features of an alternating station in detail, describing what have been our results and the best practice in my experience.

I will begin with the switchboard—a subject often discussed in these meetings, but none the less important—and I will try as much as possible not to go over the same beaten track, with possibly some new details. A circuit board is eminently better made of marble, as a matter of both safety, durability and appearance, and should have plenty of space between it and the wall. The dynamo bus wires should run in horizontal rows on the back, with plug holes extending through to the front, to connect to either side of each changing switch. There is a changing switch, of course, for each feeder or circuit, and all bus wires can be connected to any particular feeder. The front of the board should be divided into perpendicular panels, each panel representing a feeder.

On the back there will be the converter for voltmeter, compensating devices, etc., and the fuse blocks. These are preferably placed on the back, as it is an unpleasant thing to have a fuse blow in a man's face, and they should not be so high on the board that they cannot be reached standing on the floor. Many of you, undoubtedly, have had trouble with a fuse arcing, and finally melting the fuse block into a conglomerate mass, or setting fire to the switchboard. There are two simple remedies for overcoming this; one is to have all fuses covered with a piece of asbestos paper rolled around the fuse wire or link in the form of a tube, a little larger on the inside diameter than the wire, to allow for radiation of heat, so that the fuse wil not melt under its rated capacity. These asbestos tubes are very easily made, and can be pasted either with shellac of silicate of soda, which is preferable, the idea being that when a fuse is blown the pent-up gases in the tube are forced out at either end so violently that the resulting arc is dissipated immediately. I believe I am not the originator of this idea, but believe we can claim the use of asbestos as our own, and which is the only substance that is practicable.

Another simple plan to prevent arcing is to have all fuse blocks placed on a narrow shelf with their faces up, as there is always a tendency in an arc to take an upward direction, owing to the current of heated air resulting from it, and in taking this direction there is a natural pulling away of the arc from the two metallic portions of the fuse block; whereas, were it in a perpendicular position with the current usually coming in at the bottom of the block, this upward tendency of the arc only completes the path across the gap, and so continues arcing. Fuse wire as now made is quite as reliable as to its carrying capacity, but, like many other good things, is not trustworthy, if abused. A lead fuse, either wire or flat link, should never be screwed down under a screw head and washer, no matter how small the carrying capacity it is intended for. This may do for a short time, but the soft metal soon loosens up, a poor contact is formed and the fuse melts from the heat thus generated, causing no end of annoyance. This applies to fuses, no matter where they are used, all over the circuit. The one way out of this is a small flat copper terminal, slotted to slide under the screw head, and soldered to each end of the fuse wire. The carrying capacity of the wire can be stamped on one terminal. These are cheaply made. A boy with a punch and die can stamp out many hundreds of them in a day, and the soldering, with a little experience, is rapidly accomplished. Had we adopted these fuses when we first began to furnish light, five years ago, and insisted on all inside wiring being fused in this manner, we should have been many dollars ahead to-day, and there would have been fewer lights out during that time.

Nine-tenths of the calls on our complaint book show a record of fuses blown in branch or main blocks of inside wiring, which we have to send men out to replace, and from repeated inquiries from these men I find that this same proportion of nine-tenths would hold good for fuses that had blown or rather melted from poor contact, due to lead becoming loose under screw heads, and from no cause of short-circuits, overloading or trouble in the wiring. We now compel all wiring contractors to use a copper terminal fuse and we ourselves replace all blown-out ones with this style; but with 75,000 lights connected up, we do not see our way clear to weeding out the old fuses just at present; so let this be a warning to those young in the business.

On the front of the switchboard we have for each section or panel a volt and ampere meter for every feeder, one over the other, and surmounting these a pilot lamp run from the converter supplying the voltmeter, whose primary should be tapped on the feeder wires above the fuse block, so that should a fuse go out quietly, as is generally the case when fuses are arranged in the manner I have mentioned, the attendant's attention will be called to the fact by the extinguishing of the pilot lamp. The changing switch, generally placed on the front of the board for each feeder, should be about breast high, so as to be easily reached to make a quick throw. I say usually placed on the front of the board, as it is only recently that a new switch has come out that has its jaws and contacts so arranged that it can be placed on the rear of the panel, with the lever extending through a slot to the front of the board. This is a matter of great safety to the switch tender, for, as stations increase in size and load, a new element of danger sometimes manifests itself in the act of throwing these changing switches. A violent arc is formed which follows across from one set of contacts to the other, throwing two dynamos in multiple through the medium of this arc, burning the attendant's face and hands, and sometimes wrecking an armature, as, of course, the two dynamos are not apt to be in synchronism when thus thrown together. Placing the switches horizontally will lessen greatly the continuance of this arc, on the same principle that I have mentioned the placing of fuse blocks on the switchboard with their faces up, and a fibre or slate partition between the jaws will prevent the arc short-circuiting the dynamo. This annoyance is only met with on feeders of considerable length and those having a large

number of converters on them. It is due to inductive discharge from converters and line, and is similar to the extra current or field discharge of a dynamo. Its occurrence depends largely upon the period in the wave phase at which the circuit is opened, and is proportional to the length of the circuit and the number of converters connected on the line. I have found this discharge to occur more frequently on circuits whose converters were partially loaded. This would naturally seem to be the result when the secondary coils of the converters were exerting no action on the primary, but I have had the most severe arcing on circuits with heavy loads. The damaging result of these arcs, however, has been entirely diminished since placing the switches horizontally, as I have described. I have spoken only of the feeder ammeters. There should, of course, be an ampere meter for each dynamo. These are preferably placed together in a group at one end of the board, so that at a glance the attendant can see what load he is carrying, or on what dynamo there remains room for more feeders as the load comes on or goes off. The regulators and rheostats can be placed at the base of the switchboard, or, much better, if there is room, in a compact row out in front of the board about four feet, on a strong framing of wood or iron, so that all the voltmeters can be watched at the same time that the adjusting of the pressure is taking place. This saves the annoyance of the attendant jumping from the rheostat out to the front to catch a glimpse of the voltmeters to see how near he has come to guessing at the right amount of resistance he should have thrown in or out. The result will be far better service if the rheostats are thus arranged.

This now brings us up to the remaining feature of the switchboard—the lightning arrester—though I cannot say that, necessary as this last-named appliance is, the switchboard is the all-important place for it. There may, however, be a lightning arrester on each side of every feeder, placed in a row on the top of the board or on the wall back of it, and a heavy copper wire running along past this row and connected to each arrester with a tap wire, and the main wire leading to a good ground in as straight a path and with as few crooks and turns as possible, as every bend offers a source of self-induction detrimental to the flow of the lightning discharge. The source of ground cannot be too perfect; have several of them radiating off to different points, to a mass of metal in a well, or soldered to a water main, so, should one fail, the others may be relied upon. The lightning arrester itself should be an instrument devoid of fuses, be capable of rupturing instantly the arc formed, and still remain set for a second discharge; should be free from all moving parts; not absorb energy, and should be so reliable and substantial that they could be set up anywhere on the line and forgotten, and still perform their duty. This may seem to you like an ideal instrument, but, so far as alternating currents are concerned, I am positive that this state of perfection has been attained in a certain arrester now on the market. There is no question about the efficacy of lightning arresters placed out on the line, if we wish to keep the lightning out of the station and protect our converters, especially in districts remote from other wires and tall buildings, as in the residence portion of lighting. It is a good plan to place one at the end of each feeder and branch main, and scattered at intervals midway on the circuit; they also are a wise protection over a large bank of transformers, notwithstanding the fact that we are taught to believe that lightning abhors an inductive resistance as nature does a vacuum, and that a collection of such resistance would be self-protection, yet it does not prevent the discharge entering the case of the converter; then it does not have to jump much more than the space of one-eighth of an inch over to the plates to ignore these inductive coils, reach the secondary outlets, and thence to the house wiring, when it generally finds an easy path to earth with the close proximity of inside wires to gas and water pipes, and especially on combination fixtures with poor insulating joints. This does not always completely burn out the converter, as oftentimes this discharge has only ruptured the primary coils on the first turn of the wire at the point where it has jumped to the frame holding the plates, and is easily repaired. I imagine this is the case when a discharge takes place when there is no dynamo current on the lines; at other times there is a complete destruction of both coils. In a great many instances we have traced converters burned out by lightning to defective insulation in the house wiring. Whether the ground actually existed before the disruptive discharge, or was caused by it, we could not always tell. I did find one place where the wire was fused to a gas pipe up in the attic, the discharge evidently having jumped through the insulation. as the wire had been carelessly left resting on the pipe. Of course, the primary fuse, having blown in the burning out of the converter. did not leave the circuit permanently grounded. We do not want the house wiring a safety valve to relieve the circuits of their static charges, therefore have lightning arresters, plenty of them, that will offer an easier path to earth across small arcing gaps, smaller than can be found in the converters; but no matter how perfect the arrester is, it is valueless unless it has a good ground connection and a straight copper wire, not smaller than No. 6, without bends or turns, connecting the two. A very convenient method I have found to make a reliable earth connection for arresters out on the lines is to dig a hole at the foot of the pole about two feet in diameter, three feet deep, and driving down through it a twelve-foot length of 1¼ inch galvanized iron pipe, having on the lower end a driven-well point to allow it to be driven easily, and a cap screwed on the upper end to prevent the sledge hammer splitting the pipe. The No. 6 wire can be more thoroughly soldered to the pipe before it is sunk. The upper end should be driven to about one foot below the surface, and the hole filled in with finely broken coke, which increases the conducting surface at that part of the earth that is the dryest, and the lower end of a twelve-foot pipe will usually be in moist earth, and can be relied on to furnish a good connection at all times. I once had an electric light man tell me that he considered a small coil of wire buried just under the surface of the earth sufficient grounding, as the rain would immediately soak the earth and make all the ground he wanted. I have observed severe lightning discharges that took place before a drop of rain had fallen.

While on the subject of the burning out of converters, I will mention an annoyance we sometimes meet with in a primary fuse blowing, arcing and welding the leading-in wires to the case, or so carbonizing the fuse box that a short-circuit is formed on the line. This will always be the case where a fuse carrying a high potential current blows in a pent-up space, with no chance for the gases to escape. The arc is being fed, and increases until a fuse is blown at the station and shuts off the supply of current. Generally, on throwing in this feeder again, after replacing the station fuse, it will be found to work all right if the wires are not fused to the converter case, or everything is not carbonized inside. We have in some instances, on its again blowing the station fuse, fused up a little heavier and finally removed the trouble, not fusing to that extent that it would wreck the armature. We are learning now that it is far preferable to have no primary fuses in the converter case, but a large primary fuse and switchbox combined, removed from the converter to protect it. We have long since discarded secondary fuses in converters, replacing them with copper wire; and let me remark here that this is what a member of this association meant when he made the statement before one of its conventions that we had been substituting copper wire for all our primary fuses, he, evidently, mistaking the primary for the secondary end of the converter. This would also be a sad mistake to make when fooling with hornets.

This short-circuiting of the line by the burning out of converter fuses and other causes led me to adopt a combined switch and fusebox on all branch lines leading from the main feeders, and we have found them of immense benefit.

The switch cuts off all connection from the line wires in fusing up, and also makes a convenient means of disconnecting that part of the circuit to locate grounds and other trouble. Then the greatest usefulness is their blowing when there is a short-circuit on the branch they protect, thus preventing every light on the rest of the circuit going out by the station fuse blowing. Then, again, it locates at once where the trouble lies by sifting it down to one of, say, twenty branch mains, by telephone calls pouring in that lights are out at such a place.

As alternating stations increase in size and larger units of dynamos are adopted—which is certainly a wise step toward economy—another class of appliances is required at the switchboard, namely, devices for independently regulating the state of pressure on any particular feeder, the dynamo pressure remaining the same. The necessity of this can readily be seen, for we will have, say, on the same dynamo, when it is of large capacity, several feeders of different loads; those carrying the greatest number of amperes requiring a higher electromotive force to overcome the drop on line, so that if this required pressure all came from one source, these feeders of lighter load would be receiving too much potential, and a large lamp breakage would be the result. Therefore, the potential of the dynamo is regulated for the lighter feeders, and pressure raisers or "boosters" used to bring up the potential still higher for the remaining feeders. The principle of these regulators is this: If we take a converter whose capacity equals the maximum load of the circuit, and connect the secondary in series with one side of the feeder, and the primary across the two sides, we are then adding the 50 volts of the secondary of the converter to the 1,000 volts of the line, raising its initial pressure five per cent. Adding a number of these in series in like manner, and having a suitable switch to throw them in or out in succession, makes a very convenient means of raising the voltage, but resembles somewhat, as I once heard it remarked, a man raising himself up by his boot straps. I have sometimes found it very useful connecting in ordinary converters at the switchboard, for temporary heavy loads, in this manner, where feeders were not provided with the regular "boosters."

Reactive or choking coils may be employed instead of "boosters," with the same end in view—i. e., the proper adjustment of pressure on feeders of unequal drop supplied from one source—only in their use they will be placed on the lighter feeders and the dynamo be made to raise the electromotive force for those having the heavier load. The first cost, I think, would be in favor of the reactive coils, but the relative economy in energy consumed would be slightly in favor of the pressure raisers.

A serious annoyance is often met with on the line from the inductive effect of two parallel circuits upon each other, causing the lights to waver or "pump," which better expresses it. When this trouble first manifests itself in a station, the engine is generally the first thing to be blamed, and the engineer is caused many sleepless nights or days in trying to remedy it.

We seldom find this effect in small stations, unless the feeders are parallel to each other for a considerable distance. It is most marked in circuits that are parallel and one of them carrying a heavy load, which exerts this inductive influence on neighboring lines on the same principle as the primary coil of a converter inducing currents in the secondary parallel to it; only in the case of this action on the lines, where each line is fed from a separate dynamo, their phases, of course, not corresponding, we have in this cross-induction a very unsteady action in the current. Annoying as this trouble is, it is one of the easiest to remedy. First, see if some combination on the switchboard will not bring about a change in affairs. Ascertain if the several lines on which this trouble is noticed cannot be all run on the same dynamo; but if this should cause this induction to appear on other circuits formerly free from it, the then remaining way is to transpose the circuits midway between the starting point and where they cease to run parallel, by inserting a break arm in each side of the line, and joining in the shape of a cross the four ends thus formed. This will neutralize and break up the trouble completely.

These topics I have touched on in my paper have been chosen as those most interesting and worthy of discussion, and with the hope that they will be of benefit to some of you, and call to mind other experiences I have not mentioned, which, if given freely before a body of this nature, will help bring about the results we are striving for—good service and dividends.

DISCUSSION.

The President: Gentlemen, you have before you one of the most interesting papers that you are likely to have an opportunity to discuss; and I trust the discussion will be free and full. The closing sentence of that paper, and the last word of that sentence, is one of interest to us all. The production of dividends is the thing we are all after; and Mr. Sterling has brought out matter which will promote that end.

Mr. Sterling being called upon for a fuller explanation of the "boosters" referred to in his paper, said that Mr. Wagner could explain it fully.

Mr. Wagner: I understand that Mr. Stillwell is to be here, and as he is the inventor of the arrangement called the "booster," or, more properly, the Stillwell regulator, he will be more competent to answer it than any one else. It is rather difficult to explain it without the use of a diagram and blackboard. It is simply a converter arrangement used to raise the potential at will on any circuit or feeder, by means of series contacts usually differing about one per cent. The regulator, as usually constructed, may be used to raise the potential on any feeder from one to twenty per cent. It is a simple converter with ordinary coils connected in the usual way in multiple with the circuit or shunt to the secondary coil, which is adjustable in length, or has a number of ends brought out, placed in series with one leg or one side of the feeder, and adding its potential to that of the line or the dynamo. That is about as well as I can explain it without the use of a blackboard.

Mr. De Camp: I would like to hear this subject discussed. I am not in this line of business, but cannot tell how soon I may be. I have heard it said that the advantages, so-called, of the alternating system for the distribution of incandescent lamps are almost entirely overcome by the many disadvantages that it has in its want of flexibility, particularly where the three-wire system is used. I confess myself ignorant of this system further than I understand that it is to save copper in the line. The Edison company, in Philadelphia, use the direct system, and are distributing from a central station over quite a large territory—say, a mile and a half from the station—to 65,000 lamps in stores. It is done from a station whose maximum output is about 35,000 or 36,000, and which station is run 24 hours daily. I am not connected with the station, but know that they are paying dividends; and that they handle these 65,000 lamps from a station capacity of about 35,000 or 36,000. In the case of a company in which I am interested they have just started into furnishing incandescent lights, using the alternating system, running two machines, one of 1,300 and the other of 1,000, and have recently bought another machine of 2,000 lights. I think from the statement that is made that this company is making some money for all these lights. I see clearly, however, that if they undertake to meet the demand for incandescent lights as the Edison company does with the arc light, and which, in my judgment, is the proper thing to do, they will not make much money, if any. In other words, if they adapt their circuits to the different kinds of incandescent lights, as we do our arc light circuits, it will result in their running a great portion of the time with an uneconomical load on each machine. I would like to know what is the relative value of the alternating system, within a prescribed circuit, say, of one or two miles, as compared with the direct system, with the machines coupled in multiple? I ask this question because I do not know how soon I may get into that business.

Mr. Wagner: In regard to the flexibility of the alternating system, and the possibility of using the station units to their utmost capacity, I have never in my practice found it necessary to run any station unit under 75 or 80 per cent. of its total capacity. By a simple switchboard arrangement it is possible to connect as many circuits to one dynamo as is desirable, and as the load falls off the station the units or dynamos are shut down and the feeders are gradually brought together on a few number of dynamos, and in that way the station apparatus can be used as economically and advantageously as with direct current. We couple the circuits together instead of coupling the machines together, and that can be done without interrupting the service for even a moment on any circuit. It has now become possible to run arc lamps as well as motors on the alternating circuits; and I think that it has at last become almost universally conceded that for most purposes the alternating current is as flexible as the direct current. In this town we cover an area extending six or seven miles from our station in several directions. The station is situated almost at the centre of the district, and in that district we have between 75,000 and 80,000 lamps; and we have never had any trouble from want of flexibility of our machines or circuits, so far.

Captain Brophy: This is a rather delicate subject for me to handle; but I want to call attention to one point. In the earlier work it has too often been the case that the only thing men considered necessary was to run out a pair of wires, paying little heed to size, drop, or anything else, and attaching transformers to them. Of course, where you have four or five circuits, neither one of them of the same size or less, you cannot couple them together and do satisfactory work; and you will find in many of the smaller stations, and for that matter in many of the larger ones, a difference in circuits, a difference of drop anywhere from 5 to 15 per cent. This is one cause of trouble that a great many stations do not seem to understand.

Mr. Wagner: This suggestion again brings up the subject of the "booster." It is just as possible with alternating circuits as with direct circuits to use feeder regulators. The feeder regulators ordinarily used simply throw

resistance in the circuits; and if there is one circuit which is run from one dynamo, or a number of dynamos connected in multiple, which has a 10 per cent. drop, all other circuits connected therewith must have resistance thrown in to bring them down to the same pressure as the one feeder with the 10 per cent. drop. That is done with feeder regulators, or by throwing resistance, or by cutting out feeders. In a properly constructed alternating system it is just as necessary to use a system of feeders and mains as with the direct system. Generally the same devices can be used for regulating either current; but the Stillwell regulator is a device which can only be used on alternating circuits, and is much more economical to use than any other form of feeder regulator using resistance, as this regulator raises the potential of any one circuit, instead of lowering it. The circuits with small amount of drop are left as they are, and those with greater load are raised in potential sufficient to bring the potential at the end of the feeder to the proper standard.

I believe it is usually customary in direct current systems to connect all the feeders and mains together, forming a complete and continuous network. It is claimed as an advantage for the purpose of keeping a uniform pressure throughout the system. It occurs to me that it has a distinct disadvantage in case of ground or trouble occurring on the line. It then becomes very difficult to locate it. In the alternating system it is used to keep each feeder and its system of mains entirely separate outside of the station, simply throwing them together in the station. Any short circuit or ground or burn-out, any trouble occurring on one of the circuits, is immediately indicated by the station instruments or fuses, and is located and confined to quite a small district. It can very much more quickly be repaired than if all the feeders were connected together, and a great number of miles of wire had to be inspected in order to find the trouble. This is one of the advantages of that kind of distribution.

Mr. De Camp: Throwing in resistance is a consumption of energy for which you get no return; and it occurs to me whether the necessity for doing that is not one of the elements against it as an economic method of distribution.

Mr. Wagner: I was going to bring up that point against the direct system. It is not necessary to do this with the Stillwell regulator, which does not throw in resistance, but simply raises the pressure with a very small loss of energy.

Mr. De Camp: I would like to ask what the average loss is at your station?

Mr. Wagner: I suppose you refer to the average loss in distributing the current. Of course, that is left largely with the engineer designing the station and the circuits. In the case of the Missouri Electric Light Company it varies from 5 to 10 per cent.; the average probably is about 8 per cent.—6 per cent. in the feeders and 2 per cent. in the mains. It depends on the proportion between the average load and the maximum load. That differs at different seasons of the year.

Prof. E. R. Weston: I presume Mr. De Camp is really seeking information that almost every other electric light man in the world is seeking, namely, what are the respective merits of the alternating current system as compared with the direct current system. The question of the distribution of energy by the two systems under discussion is receiving great attention both on this side and the other side of the Atlantic. At the present moment I do not think any one is in a position to fully answer the question Mr. De Camp raises, namely, which is the more economical of the two systems. The systems as established here differ radically in one respect at least from the systems established on the other side. Here, for the purpose of economy in the first cost, a very high rate of alternation has been adopted. From present experience it seems as though this was a fundamental mistake, and that the mistake will be more apparent as the system has to be forced under ground, which it will sooner or later. We must all recognize the fact that any system of aerial conductors can never give us the safe and sure service which is necessary to enable us to compete with a satisfactory and reliable source of illumination such as gas. If our alternating current systems of this country were forced under ground, the loss would be, undoubtedly, greatly increased; but what the losses are exactly at present I have not been able to find out. No one seems to have made any special effort to determine them, and to ascertain exactly how they are distributed. With the direct system the losses are at the lowest point, and are very small, indeed, when the load is very light. The energy consumed then is practically what you use in the lamps; but in the alternating sytems there is an increase of loss in the converters, as we readily understand. The difficulty of dealing with and ascertaining what these losses are through the wires is serious indeed; and it is impossible, almost, to arrive at them from the actual running plant, because it is very difficult to ascertain the total number of lights in circuit and how these lights are distributed. To make a test, therefore, that would be really satisfactory, to ascertain the commercial efficiency of the alternating versus the direct current system, involves a great deal of labor and careful thought. The constant growth of the alternating current system indicates, however. one thing surely, namely, that it is filling a long felt want and that it is a money-making investment, at least, for a large number of people. Whether the system as it exists in this country to-day will not be radically modified in the next few years so as to approach more closely the systems of Europe, is a question; but I think it will. I think that will undoubtedly be done, and the tendency will be toward a lower rate of alternation and greater general efficiency. If any gentleman here has made a careful determination of the energy transformed, and has compared that with the energy actually used in the lamps, it ought to be brought out. It is a matter that everybody is seeking light on.

Of course, you can get a general idea of the efficiency of the alternating system by keeping records of the total output per hour as indicated by the instruments, supposing them to be reliable, and then summing these up at the end of the month, or at shorter periods, if possible, ascertaining what your wattmeters or recording instruments indicate. You would have a rough check in that way. I noticed one remark in the paper in regard to the use of instruments. Instruments are generally placed on the switchboard, and quite frequently so near to the other apparatus as to make their indications unreliable. Some six or eight months ago I had a case of this kind called to my attention. A concern in Philadelphia required a very large amperemeter (three thousand amperes) to indicate the total load on the dynamos. In addition to that, they had provided the switchboard with some six or eight voltmeters, to indicate the voltage of the different machines. This was on the direct current system. Right behind these voltmeters, two inches or less away from them, was a bus bar designed to carry one thousand amperes. It is claimed that these instruments are not affected by external magnetic fields, but are practically not permanently affected by them. That may be true, but it does not follow that they would indicate correctly under the conditions of their use as named above. Right behind them we had to deal with a current that may vary anywhere from a few amperes up to a thousand, and under these circumstances the voltmeters would never indicate correctly, not even if they were calibrated in position, because they have the variable current behind them, which would variably affect the value of the indications according to its strength. The paper just read speaks of the use of instruments for the alternating current. Now it must not be supposed that the indications of alternating current instruments cannot be affected by alternating currents. It depends on their design and construction. A great deal more care and attention ought to be paid to putting the instruments in such place as will insure their being in a position where they are free from the disturbing causes of external magnetic fields indicating correctly. If this precaution is not taken you are frequently entirely misled and the instruments are blamed for troubles which are not inherent.

Mr. Blaxter: I would like to ask Mr. Weston a question. Does he think that in going underground with the alternating system that the loss would be greater with the high number of alternations than with the overhead system?

Mr. Weston: I should expect the loss to be greater on account of the inductive influences.

Mr. Blaxter: Would not the concentric system of wiring obviate a good deal of that trouble? Would it not reduce it to such an extent that it would not be any more than with the overhead system?

Prof. Weston: The concentric system is being tried on the other side, and they have met with serious difficulties. I think it will be found that there is a greater loss underground.

Mr. Hammer: There is one point in connection with the comparison between the two currents which has been an interesting one to me, and I would like to know whether there are any gentlemen who have had extensive experience on this point. I refer to the relative life of the incandescent lamp on a continuous and on an alternating current. This has been stated by various parties to be a very slight difference. I remember one of the oldest engineers in Europe quite a number of years ago published a statement shortly after the introduction of incandescent lighting, that the lamp would last longer with the alternating than with the continuous current; but within a brief period afterward they published another statement that the opposite was the case. It is a well known fact, however, that an incandescent lamp will last longer at a lower rate than at a higher rate of alternation. The question is, what is the relative life of a set of lamps working upon an alternating circuit, compared with a set working on the direct circuit, under the same conditions, or as nearly as possible under the same conditions? I would like to know whether any gentlemen here who have central stations, and who have made tests, will give their experience. It is one of the points which bears on the commercial value of the alternating compared with the continuous current.

Mr. Blaxter: Comparing the alternating circuit with the direct current, I do not think I have noticed any difference in the life of the lamps; but one thing I have noticed, and that is, that a lamp in the city in a store will burn out in a less number of hours than a lamp in a residence. Vibration, I think, has something to do with it. I had a lamp in my own house and burned it considerably every day. If that was in the city, I think three months would settle it. I think the shaking of buildings in the city has a serious effect on the life of lamps.

Mr. Wirt, of Chicago: I think the difference in the life of lamps in stores and residences can be accounted for. The residence is generally further from the centre of distribution and the pressure is generally lower. I have made tests of that kind, and I think it is pretty safe to say that is the usual state of the case. Regarding the difference in the life of lamps on the alternating and direct current, I think that question has almost been settled by laboratory tests and the result of large experience. It has not been claimed for some time now, to my knowledge, that either system is far superior to the other as regards the lamp life. A recent report on this subject was made in Europe, and it summed up the matter something like this: It seems to us that these results would dispose of the question of the continuity of the life of the lamp on the alternating as compared with the direct current; the results having shown that there is practically no difference between the two.

Mr. Kilbourne, of Seattle: The question as to the relative value of the two systems depends largely on the field you are going to operate in. In Seattle we have both systems, and find they do not conflict; we also find the alternating system just as flexible, and in some respects more flexible than the direct system. If you have a station which is so situated that you do not expect to go beyond a certain limited distance from the station, and your load is liable to be light at certain times of the day, and you want to run all day, there is no question that the direct current is the better and cheaper. The chronic condition of most stations is light loads, and the direct system under these conditions is the more economical; but it is impossible to go beyond a certain distance with the direct current, so I think the question largely solves itself.

Thermal Storage for Central Stations.

BY GEO. FORBES.

When asked to give you a paper on some electric lighting subject, it seemed to me that I could not choose a better one than "Thermal Storage for Central Stations," which has had so much attention directed to it lately in England. It has long been evident that storage of some kind might lead to great economy in central station work. The reason of this is that the demand for light has, in most cities, a maximum for only two or three hours of the day. Not only do we require to have plant lying idle all the rest of the day, but the expense of working for those few hours is increased by its temporary character. This loss of economy has occurred both in engines and boilers. Underloaded engines are very inefficient and use up a lot of coal. The defect is, however, got over in all important central stations by having at least a few engines of small power to carry the day load. We are thus able to have engines in use always working at their most economical load; that is, near full load. The other loss in economy comes from the boilers which have to be fired up and heated only for a few hours' work, and then banked or else allowed to cool down. This loss cannot be overcome by working the ordinary plant in any special manner. At the Kensington station, in London, where the engines are always working at an economical load, five pounds of coal are used per electrical horse power per hour, whereas in tests of 24 hours' duration, made on the same plant, with all the boilers doing full work, only 3½ pounds of coal were required for the same duty. If, then, we could have storage of any kind by which power is absorbed at times of light load and given off at times of heavy load, we should save 1½ pounds of coal per horse power per hour.

Many people have thought that storage batteries would overcome this trouble. It does so; but at an enormous capital expenditure in storage batteries, with a loss of 20 per cent. in the energy given to the batteries, and with a depreciation account which no one would put at a less figure than 12 per cent per annum.

I have previously proposed that in a hilly country the boilers and engines should be working all the twenty-four hours, at the rate of the average demand, and that they should be used to pump water through a pipe to a high reservoir at least 500 feet above the pumping station. At the lower end of the pipe turbines are placed driving dynamos. During the daytime the reservoir is being filled, and in the evening it is being emptied. This produces a saving in boilers and the substitution of cheap turbines and a small number of efficient pumping engines for a large number of less efficient engines to drive dynamos. It also reduces the coal consumption from five pounds to three pounds per horse power per hour. In a paper read last year before the British Association for the Advancement of Science, I showed that this plan could easily be adopted at Edinburgh, in Scotland, the saving in capital and annual expenses being both very large.

But it is not every city that has these advantages, and I wish now to introduce to your notice the excellent scheme which has been invented by Mr. Druitt Halpin, of England.

He proposes to put up boilers only of the average capacity and to work them day and night. At times of light load the steam is carried through pipes into large iron reservoirs of cheap construction, and is used to heat up the water in these reservoirs to a high temperature and pressure. When the heavy demand comes on in the evening, steam is drawn from these reservoirs. The losses of heat from radiation from the reservoirs can be made very small, indeed, with proper lagging, in fact, quite imperceptible.

This is the general scheme of Mr. Halpin's plan. But it has two advantages which are not so apparent at first sight. One is the purity of water supplied to the boilers. Mr. Halpin's pumps feed water into the hot reservoirs when impurities are precipitated in a place where they can do no harm. The boilers, on the other hand, are fed from this pure water in the reservoirs.

The other incidental advantage of the system is that priming in the boiler does not cause any inconvenience, as the steam is all supplied to the engines from the reservoirs. Now, it has been found from the experience with the water tube boilers, which are so much used in this country, that only three pounds of coal per hour can be burned per square foot of heating surface, on account of excessive priming, instead of the six pounds per square foot which we can use with the Cornish or Lancashire boilers, and which might be used with water tube boilers if priming were no objection. Thus it appears that the adoption of Mr. Halpin's system not only reduces the number of boilers that we require, but also doubles the capacity of each boiler.

Mr. Halpin has worked out the relative cost of supplying machinery to the central stations of Berlin—(1) without any storage, (2) with storage batteries and (3) with thermal storage. He first selected this station because the output at each hour of the day all through the year was published before any other central station had published similar data. In this system there are four central stations, giving off about 10,000 electrical horse power.

The load at different times of the day is such as to lead to the following data:

Maximum load	7,500 kilowatts.
Mean load	2,030 "
Excess of maximum above mean	3 080 "
Duration of ditto	7.5 hours.

Now Mr. Halpin claims that he can replace 22 boilers for working in the ordinary way by five boilers and 92 of his storage cylinders, which are cheap to construct, and have, necessarily, a small depreciation. His claims, which, I must admit, seem to be quite well founded, are that while laying out somewhat more capital on his plan, he gets a very large return from the extra capital spent. He sums up the cost of the thermal storage system as follows:

5 Babcock & Wilcox boilers	$27,050
Boiler house	9,500
Chimney	4,800
Cylinder house	33,300
92 cylinders	184,050
Total	$258,700

and he puts the cost under the existing system at $182,700.

Now, if we charge 10 per cent. to annual depreciation of boilers and only 5 per cent. on the iron cylinders, which really seems a very fair value, then the annual interest and depreciation comes out almost the same for both systems, thus:

EXISTING SYSTEM.		THERMAL STORAGE.	
5% on $182,700 capital	$9,135	5% on $258,700 capital	$12,935
10% on $117,850 boilers	11,785	10% on $27,050 boilers	2,705
4% on $64,850 building	2,600	4% on $47,050 buildings	1,900
		5% on $18,400 cylinders	9,200
	$23,520		$26,740

Annual charges against thermal storage, $3,220; but the annual saving in coal is, in this special case, 7,000 tons; besides the saving in ash removals and firing. Mr. Halpin thus obtains figures giving an annual saving of $36,530 to pay interest on extra capital of $75,000, with coal about $5 per ton.

Now, the only kind of storage against which Mr. Halpin has to compete, when high land is not available for utilizing water storage, is the storage battery; and from his figures, which seem fair to me, the extra capital required is $732,200, and the total annual extra cost is $110,570, which shows a great advantage in favor of thermal storage.

I consider that all these figures are very conservative, and that in these days, when we are learning to realize the importance of cutting down working expenses in central stations, this system must, necessarily, occupy an important place. But it is of peculiar interest to me, owing to its applicability to a kind of work to which I have devoted a large part of my time in the last seven or eight years. I refer to the burning of the house refuse and garbage in our cities. The furnaces in which this cremation is accomplished are generally called "Destructors." It has been one of the great objects before me of late years to have this title abolished, and to justify their being called "Utilizers." The improvements which we have introduced in the methods of burning refuse are so great that I can now undertake to produce the following results:

Taking the ordinary house refuse, consisting of ashes, coal, wood, paper, old boots, vegetables, bones and scraps, crockery, tin cans, iron pots, bottles, and adding thereto occasionally dead cats and dogs, infected mattresses and condemned meat, I can throw the whole of these, without sorting, upon the furnaces, and without producing any offensive odors or dust, I can raise the temperature of the gases where they reach the boilers to over 2,000 degrees Fahrenheit. From my data as to the amount collected in different houses in England per head of the population, I find that from the house refuse of any town I can supply enough steam to generate electric light at the rate of one 16-c. p. lamp per head of the population for two hours every night of the year. By doing this, I am saving the municipality from $10,000 to $20,000 per annum per 100,000 inhabitants for the cost of removal of house refuse. I am preventing these objectionable materials from being dumped in the outskirts of the city, where building operations will soon commence, or in the neghboring harbors or lakes, either of which plan is a nuisance and unhealthy. The only resulting material is a clinker, which can be broken up and which, when mixed with cement, makes admirable concrete or artificial stone for paving, while by itself it makes excellent foundations for roads.

Now these enormous advantages, of the truth of which we have ample proof, from a practice extending over nearly twenty years in England, can be worked at full economy only when the burning of refuse is quite continuous and uniform. To do this we must have storage of some kind. In hilly countries the plan I have advocated of water storage is generally available, and is very economical. In all other cases thermal storage is far and away the most economical mode of working, and, in this line alone, if in no other, I have always said, from the first moment I knew of Mr. Halpin's invention, that we have here the last item which was wanting in order to do away with the barbarous methods generally adopted for getting rid of house refuse, and, at the same time, utilizing that refuse in a manner that will confer material benefits on all the inhabitants of a great town, and pecuniary advantages on those who undertake the work.

DISCUSSION.

The president called on Dr. Louis Bell to open the discussion on the paper.

Dr. Bell: I am rather surprised at this sudden call for an opinion upon the subject, to which I have not given nearly the consideration which it deserves. I think we are fully alive, however, to the importance of testing this kind of storage work to which Prof. Forbes has called our attention. In our country it seems to me that his plan of storing water power is one that can be worked successfully, quite aside from the matter of thermal storage. There are certain parts of our country where coal is very dear, and where everything in the way of power that can be saved should be saved. There are places that are so situated as regards topography that the water storage scheme could, I believe, be successfully worked. For example, there are many places in the western part of the country, through the Rocky Mountain section and westward, where coal is to be had, to be sure, but it is altogether too dear for economic use. There is a little water to be had, but the supply is not steady enough for working the stations by water power direct. In such cases it seems as though the pumping of the available water into reservoirs might serve a very useful purpose.

As to the thermal storage itself, I hardly feel competent to speak in extenso. I will simply say that it seems to present a very important possibility; and I can heartily add that I most cordially agree with Prof. Forbes in the great value of working out a commercial system for the destruction of garbage. New Yorkers especially would welcome this means of disposing of garbage, as it is an unpleasant thing to find yourself in a drift of it when bathing in the waters adjacent to the city. It would seem as though by the help of either the thermal storage or water storage it might be possible in a good many cities to get rid of the garbage, and at the same time get a great deal of power which could be utilized for lighting or other purposes. I think that thermal storage itself is a matter to which we should give our very careful attention.

Mr. De Camp: Do I understand that the system is to first make the water hot in the boilers when there is no use for the steam, and then pass it into the reservoirs, which constitute the economic points?

Prof. Forbes: Yes, sir; he passes the steam through a pipe into the water of the reservoirs, and so heats up the water of the reservoir, the top of the reservoir being filled with steam, to a pressure greatly increasing as the water is heated up higher and higher.

Mr. De Camp: Up to what temperature does he get the water in these reservoirs?

Prof. Forbes: The highest temperature is about 407 degrees; he works from about 350 to 407. I think that corresponds to the variation between 120 pounds pressure and 250.

Mr. De Camp: When the time arrives that he is at his maximum use of power, does he put the hot water that is in these reservoirs back into his boiler for generating steam of sufficient pressure to run his engines?

Prof. Forbes: No, sir; the steam in the reservoir under normal conditions, we will say, is under 250 pounds pressure, and as he gradually takes off the steam in the reservoir reducing the pressure, the water, of course, begins to boil, and gives off still more steam, so that he always has a supply of steam until the pressure in the reservoir has been reduced down to the working pressure of the engines. When he gets below that, of course, he has exhausted his steam, and has to put in more power from his boilers.

Mr. De Camp: He has to re-enforce it from his boilers? Permit me as a layman to say that there seems to be an element of perpetual motion about that. In our station we carry our exhaust into two receiving tanks and exhaust receivers, through which all the water passes, and then from that it flows into two storage tanks, of 18,000 gallons capacity each, and the water in these two tanks stands at a temperature of 185 to 190 degrees. I don't know to what extent this is practiced; but, of course, it is not new.

Prof. Forbes: The method just described by Mr. De Camp is, of course, one of the numerous methods, using the waste heat in the exhaust for heating up the feed water. Of course, you are saving a lot of waste heat which would otherwise go up the chimney. Mr. Halpin's scheme is for a totally different purpose. It is to get over the waste of coal that there is in heating up the boilers just for a few hours' work at maximum load in the evening. Owing to this fact you have to pile on the coal for a short time, probably using forced draught, and working the boilers up, and wasting a great deal of coal in heating them up to the required degree, and then after you have got them nicely to work you have to let them go down. That, as I pointed out, in actual central station practice, means an addition of something like 40 per cent. to the coal bill, and that is the economy which Mr. Halpin seeks to introduce.

Mr. Bradley: The idea here seems to be that as the steam comes into the reservoirs it is condensed and converted into water, the water converted into heat and the temperature is raised. As the water boils it gives off its heat in the shape of steam, which runs the engine. There is no element of perpetual motion about it. It is a question of storage all the way through. Nature has stored the energy in the coal. This proposition is to store the energy in the steam as it is made in the boiler. Mr. Forbes' proposition is to store the power after he has made the power in the form of steam; the storage battery stores the energy after it is made in the form of electricity.

Mr. Haines: I would like to ask Prof. Forbes to give us a comparison of the efficiency of storage of water—raising water to a height—and the efficiency of the storage of steam in his cylinders, which would be of interest to many of us.

Prof. Forbes: The gentleman has asked me for a comparison of the relative efficiency or cost of the system of the storage of water, which I had myself proposed, and that of thermal storage, which Mr. Halpin has proposed. The running expense is almost the same in the two; but the economy of capital, if your reservoir is anywhere near your pumping station, is very much in favor of the water storage. The water storage takes off about 30 per cent. from the cost of a central station built upon the ordinary lines. That was so in the detailed plans which I worked out for the city of Edinburgh, Scotland. Thirty per cent. from the cost of doing it in the ordinary way. The thermal storage is rather more expensive to erect, but the annual saving on these two systems is about the same.

Mr. Hammer: I heard a lecture that Prof. Forbes delivered in London, on the subject of the utilization of rubbish in producing power. I would like to know what were the results of the experiments in London. Also will he please state, if a normal central station will use five pounds of coal per horse power hour, what the amount of rubbish is compared with coal, to produce the same power?

> "The alchemist old, as I'm sure you're aware,
> Turned stone into gold by fasting and prayer;
> The alchemist new, Forbes his name, has a plan
> For turning town rubbish to light by a dam!"
> —"The Electrical World," Aug. 20, 1892.

Prof. Forbes: Mr. Hammer has asked me a very pertinent question as to the amount of house refuse we find is necessary to take the place of the five pounds of coal. I have a large number of experimental data to be guided by. I may tell you that in the old-fashioned method of building destructors it took ten pounds of refuse to produce the effect of one pound of good Welsh coal. Now we have reduced that quantity down to about five or six pounds of refuse to be equivalent to one pound of coal; therefore, in answer to Mr. Hammer's question it would take about thirty pounds of house refuse to equal five pounds of coal.

Mr. T. C. Smith: I would say to the members of the association that a very common and familiar example of much the same process that Prof Forbes has outlined can be seen in the boiler and engines commonly used for hoisting purposes. Take a small five horse power boiler, with pretty large storage capacity, and they will use that and drive an engine which will develop from 20 to 30 h. p. The fire is kept going at the same steady rate all day long, and in the intervals of the hoisting, when the load is being lowered, the pressure will rise to 120 pounds. When the hoisting is being actually done the pressure will drop back to 100, or down to 80 pounds. Then the engine is at rest for a while, but the boiler keeps on making steam and storing it. In this way we are enabled to do with a small boiler work that is far beyond its capacity. The same thing can be seen in nearly every elevator plant, where the boiler is much less in horse power capacity than the pump which it drives. The same thing can be seen to a very much greater extent in railway power stations, where in order to meet the demand upon the trolley they can exert a much greater horse power than is normally provided for by their equipment. The greatest doubt in my mind as to the success of this storage system is that identically the same thing was tried in the city of Boston, where a company was formed for the purpose of distributing power by hot water, called liquid steam, which simply meant water at a pressure and temperature corresponding to about 400 pounds, I believe. This water was carried through pipes, and when it was desired to use it in any building, the moment it escaped it became steam. The practical working of the plant was first-rate. The thing collapsed, however, through an unexpected difficulty; and that was the tremendous and rapid destruction of the pipes from the continual use in them of the highly heated water. How that would affect a plant of this kind where you could make it from steel, I do not know. Perhaps Prof. Forbes could give us some information on that point. The effect on the iron pipes, as used in the case cited, was to cause its abandonment in that city; and I understand the old material was sold recently as scrap.

Prof. Forbes: I am obliged to Mr. Smith for his excel-

lent remarks on this point. They are most appropriate. He has spoken about the hoists being practically worked on the same lines. I may mention that water storage, which I have also advocated, has been used similarly for hoists and for hydraulic accumulators by Lord Armstrong, very largely indeed.

Mr. Wirt: The fireless steam locomotive is also another example in point. We had these engines in service in Chicago for many years, during which they did good service, and were finally replaced by the cable line. These locomotives were of the ordinary type, but had larger steam boilers than usual. The boilers had no furnaces and were charged at one end with hot water under high pressure from an ordinary stationary steam boiler. The locomotive ran a round trip of six or eight miles, perhaps, and pulled very heavy cars and heavy loads, giving regular and satisfactory service, winter and summer. I was not present during the reading of the entire paper; and I would like to know why the storage battery fails in comparison with steam storage; whether it is depreciation, lack of efficiency, or interest charges. It is pretty evident that there is an advantage in working dynamos at full power twenty-four hours a day, as well as working the engines. It is also evident that if storage batteries are used, there is a saving on both engines and dynamos, which we do not get in the case of steam storage.

Prof. Forbes: I made a direct comparison between the cost of batteries and of the thermal storage system. The loss in connection with the storage battery includes all three of the items you named. Increased original expenditure in putting down storage batteries, which is far greater than the dynamos and machinery they replace, and also the great loss of efficiency—80 per cent. being the efficiency at which they work, there being a loss of 20 per cent. of coal—and also the depreciating account, which, I think, every one must admit is about 12 per cent per annum. I have installed numerous storage batteries, but have never done so in a central station. I have done my best to try to find an economy in them, and if it were feasible would have recommended them to central stations; but I have never found that batteries introduced in central stations would be a large economy. I know there are others who hold different views; but my experience leads me to the belief expressed. Storage batteries have their appropriate places, and I would like to see them much more used than at present in this country. There are a number of storage batteries that are available, and yet no one seems to work at them here. I have been told that it has been a question of patents; but this is hardly a reason, for some of the best batteries are founded on the Plante system, and that is open to the whole world. Litigation is also said to be the cause of the failure of a more general use of storage batteries. I regret exceedingly that they have not been adopted in their appropriate places in this country.

Mr. Stillwell: I want to say a few words in regard to the saving being effected at an early or late step in the process of transforming the potential energy of coal into light or power for sale. It seems to me that we should bring out the fact that a great deal depends upon the relative length of these steps. The central station man who is paying for energy in the form of coal and selling it in the form of light is losing various amounts at each step of the process, but up to the present time he is losing far more before it gets to the dynamo than he is after it leaves the dynamo. I have made a few figures to illustrate this. Suppose we have 1,000 h. p. potential in the coal which we are burning under our boilers. I think the best figures which steam engineers will claim for the proportion of that coal or energy which they will deliver in the form of mechanical power to the dynamos in a station that is continuously operating will be about 10 per cent. Now, if we apply Prof. Forbes' figures, obtained from records at the Kensington station, we will find that under the variable load he loses about 3 per cent. of that; and it is this amount of the energy, which is really a very large amount at that stage, which this scheme of Mr. Halpin proposes to economize. Of the 7 per cent. that at the Kensington station, we will assume, is delivered to the dynamos, I think it can be demonstrated that the dynamos, the distributing circuits, under a properly arranged system, will deliver to the terminals or lamps about 8 per cent., or 5 6-10ths per cent. of the initial energy of our coal. We again suffer a relatively heavy loss, because up to the present time our incandescent lamps give us but a small portion of the energy they receive in the form of light. I estimate that out of the 1,000 h. p. that the central station man buys in the form of energy in coal, he may be able to sell 2 8-10ths in the form of light. He has lost in the various steps about 930 h. p. before he has reached the dynamo. In the electrical apparatus down to the lamp he loses. I am glad to know that the steam engineers are attacking this problem of waste energy in the steam plants in a way that promises success.

Mr. Smith: We have come to the conclusion that it would not pay to have storage batteries in a large building for the purpose of getting rid of night running. We have come to the conclusion that it will cost you as much to get your light from your battery, and you will burn the same amount of coal, for the reason that you at once lose 20 per cent. of your energy in the battery. It will be necessary to employ practically the same force to look after the storage batteries as to man the engines, and we have failed to see that there will be any economy in it.

Prof. Forbes: As to the attendance required in the care of storage batteries, that thing has been minimized on the other side. We find that we can instruct a person of ordinary intelligence in the care of the batteries in a few hours, and often this duty will fall to the carpenter, or gardener, or even butler, on some of the large estates. Even in the larger plants, we do not think it necessary to have any one in constant service; but we have instituted a system of daily and weekly inspection of the apparatus to see that everything works efficiently and to supply defective parts, and, on the whole, we meet with much success.

Dr. Bell: I think one reason why the storage battery has been such a failure on this side of the Atlantic is because it has been exploited from the time it first made its appearance here for the purpose of street car traction or other purposes to which it is least adapted, on account of the racking of the batteries in going over rough tracks, and also on account of the frightful variations of the load, which destroy the efficiency of the battery and causes "buckling" and rapid deterioration of the plates. It has been tried with a pertinacity worthy of a better cause; but the net result has been failure in this respect. It is a fact that we have put the storage battery to the hardest service that could be imagined, and that has caused the storage battery to fall into disrepute here. If it had been started in the places in which it belongs—isolated plants—such as Prof. Forbes referred to, it would have gotten far greater headway in this country, and it is possible that some of the experiments in using it for traction would not have been such lamentable failures.

Mr. Hammer: I think another reason is that in England, France and Germany they use accumulators about the size of a trunk. Probably the small depreciation and commercial character of these accumulators is, to a considerable extent, due to the massiveness and the mechanical strength of the plates, and the cases in which the accumulator plates are placed.

Prof. Forbes: It is perfectly true that in many of the European central stations each accumulator cell is about the size of the bath they gave me in my hotel. I do not, however, think it is true that the size of the cells enhances sensibly their efficiency or the number of plates that they contain. The smaller cells, as long as they are large enough to be made in a solid, mechanical manner, last just as well, and their efficiency is relatively just as good as the large ones.

Long Distance Transmission of Power

BY CHARLES S. BRADLEY.

It is supposed that there was a time when man did not know of fire; that it was a discovery, and great must have been the discoverer among his fellows if they did appreciate the importance of combustion, as we now call it. Without it, man could not exist in these colder climates and must have hovered about the equator. It now not only provides us with a means of comfort in the winter's cold, but also gives us light and power. The last decade has given us this light and power in much improved form by the aid of that silent mysterious agency—electricity. If one has to go into the woods and cut his own wood to keep warm, almost half of his time is taken up in the chopping and hauling; so, too, in supplying the fuel to a steam engine, much labor of human hands is required, especially if the source of fuel is distant from the point of use. By organization, by careful preparation and the construction of permanent works, how wonderfully man increases his comforts and reduces his hours of toil. If a man were to try to light his house with incandescent lamps, and do it with his own power, his whole energy would be consumed in one light. If he were to try to propel his own lathe he could turn but a small one and leave himself no leisure time. It now lies within our means to build an electric transmission of power plant from coal mine to city, which shall cost $300,000, and will transmit 5,000 h. p.; this plant will do the work of 30,000 men steadily day and night, year in and year out, and once placed will last a lifetime. The $300,000 represents the work of the 30,000 men for about four days, or an outlay of $10 each; thus these men can build a plant in four days that will do more work during their whole lives than they can. Can anything appeal to the imagination of man with more force? The energy of 5,000 horses transmitted noiselessly over a small wire, the coal from the mine placed by one act immediately beneath the boilers, the energy thence running to its destination without any labor from man; the air to supply combustion taken in the country, thus not robbing the human being gasping for breath in the city; the smoke and foul gases being thrown off where they will do no harm. Think of a city free from smoke, its cars, elevators, shops, run and lighted by electricity which shall be generated miles away. I have not said houses heated, but I hope that before 1900 we may say this also. The present obstacle to heating by electricity is the inefficiency of the steam engine. Many are looking for the direct conversion of the energy of coal into electricity. There is no doubt that it can be done, but I fear it will never be economical, for we must depend upon the combustion of the coal in the oxygen of the air. The oxygen is just as necessary as the coal, but, being ever present, people neglect to consider how important it is. There is no other element in nature which can replace oxygen for this use. The only way we can get the energy at low cost is by the chemical combination of these two substances—coal and oxygen. The ordinary combustion where the air passes through the coal admits of the production of heat only; for the electrical resistances, although the spaces may, by inventive genius, be made as small as the atoms themselves, will be so great as to prevent any commercial current from flowing. The thermopile offers a way to use heat, but when heat has once been produced we cannot expect to convert it to a higher form of energy without great loss. If we solve this problem, we must catch the energy as it issues from the chemical combination. The only way now known to man of converting chemical energy directly to electricity is illustrated in the primary battery, where a conducting electrolyte forms a path for the current, and at the same time carries the elements that are to be consumed toward each other. This to all appearances is inherent. It necessitates that the oxygen shall have abandoned the gaseous state and entered the liquid. The coal demands for working a high temperature; therefore, the oxygen must have entered liquid condition and stays so at high temperatures. There are substances, such as permanganate of soda and the chromates, that seem to approach very close to filling these requirements as an electrolyte; that is, they will at high temperatures absorb oxygen from the air. They will also act chemically on the coal and produce a current. But now we are coming to the limitation again. The specific resistance of these substances is too high and the electromotive force too low, being between .9 and 1 volt, to give a reasonable amount of power from a given size of apparatus. The most promising of all fields to increase the efficiency of the conversion, I believe, lies in the gas engine; the atmospheric gas engine of Otto Langen having reached the high efficiency of 72 per cent. In this engine the piston is allowed to shoot up by the explosion and do its work in the descent. There seem to have been mechanical difficulties in the way of the success of this machine, but these can be overcome. Then, suppose we have an efficiency of 72 in an engine and 75 per cent. in transmission, we will have, all told, 54 per cent. of the energy of the coal delivered to point of consumption, which will make electrical heating not only possible but preferable to any or all other forms. Thus we may hope at no distant day to burn all coal necessary for the uses of a great city at the mine. Farther, we may take from the coal first its chemicals, which have become so valuable in the arts; then use the balance as gas in our engines.

For the electrical transmission of power we have two general systems—the alternating and direct. The multiphase alternating was advertised extensively by the Lauffen-Frankfort plant in 1891. This pioneer plant was built by much sacrifice of time and money, and we owe gratitude and honor to these men whose indefatigable efforts accomplished the beginning of an art which is destined to revolutionize the social status of mankind. This plant proved conclusively that very high voltages could be successfully used and the insulation maintained. This is the whole thing in a nutshell; the choice of this or that particular way of generating and using the energy is of secondary importance, and will vary with each situation; surprising as it may seem, the maintenance of the insulation was the least trouble in the operation of this plant. One of the greatest, the interference with the telegraph which belongs to the German government; and when the German government says "Stop," it means stop (in Germany). The next difficulty in importance is the static induction; each wire, being so long and exposing so much surface, becomes a reservoir to hold electricity, and the generator must fill this reservoir on each impulse before it can deliver energy at the distant end. When the generator reverses the direction of current, as it does some 100 times per second in the alternating, this reservoir must be discharged and filled with electricity of opposite sign; that is, if the first impulse to a given wire was positive and fills its capacity with the positive electricity, the reverse impulse must discharge the positive and then fill the reservoir with negative electricity. This operation consumes but little power; it is an ebb and flow, as it were. The trouble, however, is that this idle current swinging back and forth occupies the carrying capacity of the generating apparatus; so much so, that I saw the fuses blown at Lauffen with no load of consequence at the Frankfort end. In damp weather the insulators become wet on the external surfaces, and this largely increases the capacity, which is more serious than the increased leakage. These difficulties vary with the length of the line and the amount of power transmitted, the surfaces being proportional to the length of line. The carrying capacity is proportional to the square of the diameter of the wire, while the static capacity is proportional to the surface, which is equivalent to being proportional to the diameter, so that the larger the amount of current transmitted the less proportional influence the static capacity has. These things must be determined by the engineer in each case. The Lauffen-Frankfort was an extreme case. First, the line was much longer than we shall expect for some time to come in practical work; second, the plant was intended for 300 h. p. and a rate of 40 phases per second. Owing to the static effects at 40, the rate had to be lowered to about 23 per second; this obliged them to run the dynamo at very much reduced speed, so that it was capable of only about 100 h. p., and this reduction increased the proportionate effect of the static charge. In long distance transmission the lines should be carried on poles whenever it is possible, for, the farther apart the conductors are, the less will be the inductive capacity; if placed under ground they will of necessity be near together. The placing in separate conduits to gain distance will not help, for the nearness of the earth is the equivalent of the nearness of the conductor of opposite sign. These things are only warnings, however, and slip out of sight with proper precaution. The multiphase alternating is the most pliable, adjustable system that has ever been conceived. It fairly entwines itself about the electrical engineer's heart. It is capable of transformation in voltage; will supply motors of either synchronous or non-synchronous type; will readily convert in motor transformer to direct current for electric railroad or direct current distribution, and thus supply direct current motors. A patent was issued to me Oct. 2, 1888, which covers this ground, and it is surprising and gratifying to read the original specification filed April 23, 1887, now nearly six years ago, and note there the complete provision for the transformation

for these varied uses. At the factory of the Fort Wayne Electric Company, I have had exceptional facilities for experimentation on the multiphase systems, some 270 different tests having been made on motors, dynamos and transformers, the record of which fills a respectable volume. If this could be given to the world, that the engineers might know what not to do, undoubtedly the wings of many a genius would be clipped. Where the power is to be delivered in compact form the direct current offers some important advantages. We can get very high voltages by a battery of machines placed in series for the generator and motor stations. The placing of machines in series for power transmission was proposed by Mr. Edison in 1880 and Prof. Thomson in 1883. Each contributed some essential improvement, but it is evident that the enormously high voltages now contemplated were not then thought of. For the generator station I prefer compound wound machines; first, that the system may be self-regulating; second, that the series coil when a machine is thrown into action shall magnetize the field in the right direction; this also requires that the switch shall close the series coil first. The shunt coil would tend to reverse until the machine has attained electromotive force enough to overcome the resistance of its own armature. In order that each machine shall be as far as possible independent of its neighbors, I prefer that it shall be short shunt, or, in other words, the shunt coil be charged direct from the brushes of each machine. I would use the 500 volt machines, and of such ampere capacity as the size of the plant demanded, and belt them all from one shaft. The 500 volts have been found safe to life and the commutator works well. Now, we must protect the insulation of the windings; the end machines where the terminal voltage, say, reaches 20,000 volts may, in case of grounds, be subjected to the piercing strain of the entire electrical pressure. It is impracticable to insulate the windings of each machine to stand any such potential; therefore, we connect the windings of the machine at some point with the frame so that it may never be subjected to a strain greater than its own voltage; next each machine foundation is thoroughly insulated from earth, and, in case this insulation fails for any reason, the fuses of the line will be blown, thus protecting the whole structure. It is easy, however, to make this foundation insulation so perfect that no derangement will take place. For this, I have struck upon a cheap plan, which was not apparent at first. Having now provided for the insulation, we must next consider the safe handling of the machines. A moment's consideration of the electrical potential of each successive machine in the series will make it evident that the whole of each machine will attain the potential of its individual position; or, beginning at one end, each successive machine will be 500 volts above the preceding one. Now, it is a well-known fact that a man may be charged to a high voltage without any inconvenience. An illustration of this is found in the stool with glass legs that we used to stand on in school and be charged up until our hair stood on end. The danger to life comes from the passage of a current through the body. Now, like standing on the stool with the glass legs, a man may be placed upon any one of these machines, and if he cannot touch any conductor to earth he is perfectly safe. We can use a wooden platform around and attached to the base of the machine, so that the man must cross it before he lays his hand on the metal part. Here, again, I want to point out how essential it is that the windings be in metallic connection with the frame for the safety of the man. It secures that no part of a machine shall exceed its own voltage, and, in case of a leakage in the foundation insulation, immediate detection. If this metallic connection were not provided and a leakage occurred in the foundation, you will readily see that it might be undetected, and a man touching the brushes and the frame would take a current through him of uncertain high voltage. At the motor station we use simple 500-volt shunt machines with the same precautions as at the generator station. Our power having been transmitted can now be converted into whatever may be demanded. If it is an electric system of distribution, we shall have the advantage of its being impossible for the high tension current to get into the system of distribution. If it is a large plant, the motor station may be subdivided into two or three parts, preferably in multiple arc, with the same potential on each. On very long lines I think the transmission must be done by direct current. To prophesy, although a temptation, is futile, for the lines of progress are not as one man would think, but as the multitude of surrounding circumstances determine.

Power Transmission for Central Stations.

BY LOUIS BELL.

This paper makes no pretense to being an exposition of the theory and practice of long distance transmission of power, nor in it shall I attempt to go into lengthy discussion as to the relative merits of various methods and divers apparatus, none of which has been in use long enough to permit a ripe judgment of its relative qualities. I shall confine myself to discussing the question of power transmission as it appeals to the man who runs a central station, bearing in mind that however much may be learned from theoretical considerations theory often needs to be chastened by facts.

If the problem arises of transmitting electrical energy from a distant point for use in light or power distribution, we must ask ourselves, before answering the all-important question of "Will it pay?" first, What are the conditions surrounding the transmission as such? and, second, What are the conditions of the distribution that is to be accomplished?

If we simply desire to take a given unit of power and transfer it in the form of electrical energy from one point to another, the facts in the case are widely different from what they would be if it is necessary either to subdivide that power unit at the receiving station, or to scatter it along the entire path of the transmission. So far as distribution is concerned, we may then divide electrical power transmission into three classes—first, the transmission of single units; second, the transmission of power to a centre of supply from which point it is to be distributed in various ways; third, supplying the power for lights and motors throughout the length of the transmission line. Each of these classes of work imposes conditions on the possible methods of transmission, and requires special consideration. In new plants, hampered in no wise by existing stations, any one of these three cases may exist, perhaps the last two more frequently than the first. Where a single motor is to be employed, the problem is exceedingly straightforward. Where a new centre of distribution is to be organized, some complications are encountered, but not serious ones. Where power is to be scattered along the line, however, conditions arise which are not altogether easy of fulfillment and require a good deal of special care and skillful engineering.

A single power unit may be delivered over ordinary working distances by apparatus of various kinds, with almost equal facility. Where a centre of distribution is to be supplied, we are often limited in a new plant to such apparatus as will cheaply and effectively enable us to distribute both light and power, but the secondary part of the problem, that is, the distribution, may be accomplished by following well known lines of work. Where scattered motors are to be served, we are still further limited on account of the inordinate variations of voltage that may occur.

To the working central station man, occupied with the details of a growing business, power transmission from a distant waterfall possesses a direct pecuniary interest, and he is most generally concerned in the practicability of either displacing his engine and swiftly diminishing coal pile by electric motors to drive his station or transmitting energy from the same distant point to help out his present plant and enable it to be enlarged. Under these conditions, the question of method becomes largely one of dollars and cents. Sometimes a considerable saving may be effected by using part of the apparatus already on hand, for example, moving his arc machines and alternating lighting machines to the water power, if it is not too far away and transmitting power only for his power circuits or direct current lighting circuits. In a general investigation of the methods which may be employed, the case stands somewhat as follows, so far as the central station man is concerned:

First, if the distance over which he is to transmit power is moderate, he may use the ordinary direct current generator and motor, displace his engine with the motor and go ahead. But, unfortunately, direct current machines of any considerable capacity are practically limited in voltage by the existence of the commutator, an article on which central station men in general waste no love. Dynamos and motors of large size cannot, individually, in the present state of the art, be satisfactorily built for more than about 1,200 volts. Machines for greater voltage have very generally broken down in the experimental stage. For very small power units, arc machines might be employed, but for the purpose of the central station man it is better to move his arc machines directly to the distant point. For voltages much in excess of that mentioned, we are then driven to the use of either direct current machines in series or alternating machines.

Where generators and motors are to be used as a single unit, direct current machines in series may be and are employed quite successfully, but as the voltage desirable on the line rises the system contains a greater number of units and becomes more complicated and difficult to apply to central station practice. For instance, it is highly desirable for the successful operation of motors in series that they should be, practically, coupled to the same shaft, and should run under similar and uniform conditions, so while there are cases in which the method of coupling in series may be both convenient and cheap, it is in my opinion better general practice to employ alternating currents, after passing the ordinary limitations of direct currents.

Here we encounter a complicated state of affairs, for the central station man who attempts to investigate the subject is immediately surrounded by a cloud of mental dust through which he sees dimly the outlines of plain alternators, bi-phase, tri-phase, and multi-phase generators and motors, condensers, Geissler tubes, six-foot fuses, electrified wallpaper, and the other properties of a well-equipped modern high-voltage electrician. The substance of the matter, however, is something as follows:

We want to use power transmission by alternating currents for two good and separate reasons—first, because we get rid of the commutator and can therefore use as high voltages as we can safely insulate in the machine; second, because by the use of transformers we can obtain for the transmission line itself any voltage which we can insulate, and thereby enormously decrease the cost of the copper which must be stowed away as permanent investment in our line.

Multiphase currents, and by this I mean currents having more than one phase, are subject to the same general laws as any other alternating currents. Their most valuable peculiarity lies in the fact that for alternating currents of more than one phase excellent motors can be built which will run at a steady speed, start under heavy load, and in general possess very much the same qualities as a well organized shunt motor of the ordinary kind. Incidentally, certain of the multiphase systems, more especially the three-phase, enjoy the advantage of effecting something of a saving in copper, under favorable circumstances up to 25 per cent. from what would be required by a plain alternating current of the same nominal voltage. This saving is merely from the fact that in the three-phase line the currents do not have their highest value at the same time, so that at any particular instant two of the wires may serve as a sort of multiple return for the third. This advantage would be immediately thrown away, if for the three currents of different phase three separate pairs of wire were employed, as it is thrown away where for two currents of different phase two independent circuits are used.

The fundamental difference between single and multiphase systems then is mainly the adaptability of the latter for driving motors, and multiphase are better than single phase motors principally in their ability to start under load, and somewhat larger output for the same weight.

Wherever, then, single motors are to be driven for operating, we will say, an electric light station, it is largely a matter of convenience whether we employ single or multiphase motors. If the former can be conveniently started they are fully competent to take care of the work, except in one special case which I will mention presently. The multiphase motors, whether synchronous or otherwise, start very freely, and may or may not be economical in cost of copper, according to the arrangements of the circuits, as I have before mentioned.

A single case in which multiphase transmission becomes of great importance when the object is to work an existing central station is in that case where railway circuits are to be supplied. A railway machine is subject to so great and violent variations of load that if it were driven by an ordinary synchronous alternating motor, the latter would run great risk of being pulled out of phase by a sudden short circuit, when it would stop and stay stopped until deliberately started up again. The multiphase motor can also be pulled out of phase, but not quite so easily, and it can be more readily started. We can, however, where railway currents are necessary, do much better than to drive the dynamos directly by motors of any kind. We can for this use start with the multiphase current, and through the medium of a single machine, scarcely more complicated than an ordinary railway dynamo, transmute this multiphase current into a direct 500 volt current of the ordinary sort. This very valuable result has been brought about through the ingenuity of my friend Mr. C. S. Bradley, who invented the device a half dozen years ago. It has lain dormant, principally because there has been no special call for power transmission of any kind until recently, but to its thorough practicability I can personally testify, as a 100 kilowatt triphase direct curent transformer which I recently tested, operated in the manner described, showed an efficiency of over 95 per cent. at full load, stood sudden variations from no output up to 100 kilowatts and back again without even a wink at the brushes, and bore up under heavy overload without difficulty. Whenever it is desirable to operate railway circuits by power derived from a distant source, these machines fulfill all practical requirements, and I believe are destined to come into very extensive use, and play an important part in the development of very long electric railroads.

To sum up this point, where single motors are to be employed for driving other electrical machinery, either synchronous, alternating or multiphase motors of various sorts can be successfully employed. Where railway dynamos form a part of the load, a particularly good result can be obtained by using for this particular portion of the work the multiphase direct current transformers. So much for the operation of existing plants by electrical transmission of power where it is merely intended to substitute a motor or motors for an engine.

Now take up the case where a centre of distribution is to be fed, consisting, it may be, in part of an existing station and in part either of extensions and new circuits from this plant or subsidiary centres of distribution having other districts of the same town. Here the problem becomes more complicated, and it is almost impossible to lay down any general procedure. Each case is best handled by itself. We can, however, enunciate certain principles which will aid in the discussion of any definite case.

First, we can feed all existing railway circuits and extensions thereof very effectively and economically by use of the triphase direct current transformer just described.

Second, we can handle all direct current incandescent systems, whether two or three wire, by means of the same type of apparatus, the triphase direct current transformer.

Third, we can successfully operate any existing alternating incandescent circuits or any extensions thereof by feeding alternating current from the distant point directly into them through banks of transformers.

Fourth, if any new centres of distribution are to be made with circuits independent of those already in existence, we can operate these circuits very effectively for both lighting and motor service if both be necessary, by employing multiphase apparatus, and right here let me say that there is one widely spread error which I desire most emphatically to contradict. It has been asserted that incandescent lighting cannot be successfully done on multiphase systems, especially triphase, since this system happens to have been most talked about. This statement is absolutely false, to my own personal experimental knowledge. Lamps can be as successfully operated on systems of two, three or more phases as on an ordinary single-phase circuit, provided equal pains be taken with the distribution of copper in the lines and the regulation of the voltage at the dynamos. If these conditions are observed, a two-phase circuit with separate wires acts substantially as if it were fed from two ordinary alternating dynamos. A triphase circuit gives a similar result, and if more phases were concerned the same would be true. If the condition of constant voltage at the centre of distribution be fulfilled, as it can be and must be for successful operation on any system whatever, two and three-phase incandescent lighting systems can and do work admirably. Furthermore, if we combine circuits, for example, if we use but three wires instead of six for the three-phase system, there is no exact equality of balance required between the lamps placed in different connections across these circuits. On the three-phase we would place lamps between each possible pair of the three wires, this arrangement gaining, as I before mentioned, in copper wire, enough to compensate for the slight inconvenience in connecting three sets of lamps instead of one or two. Branches can be run from any two wires of the triphase arrangement, and lights placed on them will act exactly as if they were placed on any ordinary alternating circuit. With such an arangement you should be able to throw off all the lights on one side of the circuit, without producing any noticeable variation in the lights of the other two branches—no more variation, for example, than you would get if on a given set of secondary mains from a common transformer you were to turn off or turn on one-third of the total number of lights. If any man comes to me and says that a three-phase system will not run lamps successfully unless there is careful balance between the lights on different sides of the circuit, I have in that statement sufficient evidence to convict him either of ignorance of the principles of wiring and dynamo regulation or of willful misrepresentation of the facts. I lay stress upon this matter of incandescent lighting in defense of multiphase systems, because it is the one upon which they have been most often misrepresented, chiefly through foreign experiments, which I do not hesitate to denounce as clumsily conducted.

In taking up the condition I have just mentioned, that of new centres of distribution, I may briefly refer to the properties of multiphase motors, which have been the subject of all sorts of curious misstatements. A multiphase motor, I do not care whether it has two or more phases, should if properly built have very nearly the properties of a good shunt motor, and not far from the same efficiency. Incidentally, it has the advantage of

having no commutator, and no necessity for any moving contacts. It starts under two, three or more times the running torque, just as a shunt motor does, and by virtue, if the torque is extreme, of a heavy starting current, just as a shunt motor would. It comes rapidly up to a nearly fixed speed, and remains nearly at that speed under variations of load. If overloaded it stops, like any other motor. In addition, it has one great merit that shunt motors do not have—that of running at nearly constant speed independent both of load and moderate variations in voltage. It is, on the whole, less thin-skinned than a shunt motor. I have experimented with a considerable number of multiphase motors of the induction type, to which I here especially refer, and although I have seen some terribly severe tests in the way of overload, I never yet saw any symptons of a burn-out. The efficiency of these machines should be and is at least within a per cent. or two of ordinary shunt motors.

There has been much discussion as to the relative merits of two and three-phase induction motors. In general the more phases, the smoother action of the machines in various respects. I have never yet seen a two-phase motor any better than a three-phase motor. I should want a pretty careful series of tests to convince me that I had seen any one as good. The difference between them, with proper design, ought not to be very great, though the three-phase has the advantage in cost of wire. There are two important points in which multiphase motors have been misrepresented, which I should like to mention.

First, it has been stated of them that they take an enormous current when running light; and, second, that they introduce a very large and most objectionable lag in the circuit, so that the apparent current on the line is much greater than the energy current. Such facts have doubtless been observed. Broadly speaking, they have been due to faulty design. A multiphase motor will always take a somewhat larger current when running idle than the corresponding direct current motor, but it takes very little more energy, as the phenomenon of lag then becomes noticeable, so that, of the apparent current running light, only a portion represents energy. It is a perfectly simple matter to cut down the current required by a multiphase motor running idle to 20 or 25 per cent. of the full load current, still retaining a motor excellent in its other properties. As motors where power is sold by meter are usually cut off when not needed, the whole question of this idle current sinks into insignificance. The same is true of the alleged lagging current. If a multiphase motor (I speak with certainty at least regarding the three-phase) of 10 or 15 h. p. should show at full load more than 10 or 12 per cent. of lagging current, I should consider it to be badly designed, so that these two questions of so-called idle current and lagging current as disturbing factors in a multiphase line can be and are reduced by proper care in designing to comparatively insignificant quantities. It has been very ingeniously suggested to give them a further shove down into oblivion by means of condensers, but it is a commercial rather than an electrical question as to whether leakage current and lag had better be thrown quite into the abyss by the added complexity of condensers or left hanging on the ragged edge without them.

In case, then, of working a central station from a distant water power where necessity for extensions or new centres of distribution exists, we have plenty of methods available. Triphase direct current transformers for railway and direct current lighting service, alternators to feed into the existing mains or to supply extensions for them and for new centres where light alone is to be employed, ordinary alternating currents; or where both light and power are necessary, multiphase apparatus which, as I have shown, is entirely applicable for such a mixed system.

I may add that there is a possibility that we may have before long practicable motors to run on an ordinary alternating circuit constructed after such methods as were suggested by Prof. Thomson a few years ago. In very small sizes they are already practicable. Brown, abroad, has been making a desperate effort to exploit these very methods on his own responsibility, and has obtained motors which run successfully, but as yet do not start well under load. From what I can learn of them, I doubt very much if they are any improvement on the motors of the same type shown by Prof. Thomson at the Paris Exhibition, or on Mr. Tesla's motors for running on a two-wire circuit.

Whatever the methods which may be employed, several serious questions must be confronted when one attempts to transmit power for supplying central station or any other apparatus. One of these which presents itself immediately is whether or not in an alternating transmission it is advisable to use step up and step down transformers. The principal determining factor in this is cost. The higher voltage we can supply direct from the machine without increasing its cost considerably, the cheaper we can make the installation. Unfortunately in building dynamos the armature coils have to be insulated, and where the voltage is very high the insulation is correspondingly thick, so that with a given amount of material, we must in building a high voltage machine take up with insulation the space which would otherwise be available for copper. The result is that a dynamo wound for 4,000 or 5,000 volts is intrinsically more expensive, unless the size be very large, than a machine wound for 1,000 or 2,000 volts, besides being considerably less reliable. Machines of such voltages as these have been built in this country and abroad, and some of them have given very fair results, but they are expensive to manufacture, at whatever prices they may have been sold in individual instances, and it is my personal opinion that where it is necessary on the score of economy to raise the voltage as high as 4,000 or 5,000 volts, it is better and cheaper, unless the units be very large, to use step up transformers and carry the voltage up to 10,000. Assuming 2,000 or 3,000 volts as the available potential obtained from the machine direct and then estimating the cost of a given installation, first using these machines, and second, using low voltage machines with step up transformers, we find that at prices ordinarily charged for apparatus and copper, the two methods become of equal cost, at a distance of somewhere about seven or eight miles. Above these distances, the step up transformers cheapen the plant, below it they increase the expense. We can draw the line at no specified given distance for the general case, but can very easily for any specific case.

The amount of drop advisable in these long distance lines will depend, of course, principally upon the relative prices for copper and the apparatus necessary. If copper be relatively cheap, it pays to employ a good deal of it. If apparatus is relatively cheap, it is better to use larger generators and allow more drop on the line. Fifteen to 20 per cent. will hit the large majority of cases on the score of economy and convenience. It should be remembered, however, that for such drops as these, good regulation is most essential, but good enough is available with the direct, alternating or multiphase machines, to make these drops thoroughly practicable. The approximate figures I have just given on the limitations of the step up transformer and on drop are the result of the investigation of a large number of concrete cases which I have had occasion recently to examine in detail and for a number of which the apparatus is now in process of manufacture. I, therefore, feel personally convinced of their practicability, both theoretically and otherwise.

But for the central station man who desires to decrease his operating expenses by the employment of electrical transmission the court of last resort is the balance sheet and the fundamental question is, "Agreed that it is practicable, will it pay?" I can give no general answer to this question, for each problem necessarily must be considered by itself. It is possible to formulate equations which will connect all the variable factors of cost and annual charges, so as to enable one to derive from them an answer to this all important question. But the character of such formula is necessarily so complex and involves so many quantities that it is generally easier to take a short cut to the result by making a few approximate estimates. I have, however, looked into the profit and loss probabilities of a large number of plants of all descriptions and in a general way one can say that power transmission to a central station will, unless the cost of developing the water power be very great, almost universally pay at distances of 10 or 12 miles or less. It will frequently pay up to 20 or 25 miles. Now and then, under extraordinary conditions (very expensive coal and very cheap water power) up to 40 or possibly even 50 miles. In using alternating currents at these long distances one naturally fears the effects of inductance in the lines and of static capacity. In very long lines, operated at high frequency, these difficulties may rise to formidable magnitudes. Knowing the dimensions of the line, the frequency and the currents, it is, however, possible to calculate the effects of these disturbing elements with great accuracy. From these calculations I feel safe in saying that within the distance mentioned inductance and static capacity constitute no serious obstacle to success, if the frequency employed be moderate; such, in other words, as one would be led to select in considering the operation of motors alone. Large generators are as readily and nearly as cheaply built for frequency of 50 or 60 as for higher ones; sometimes more easily. Under these circumstances, I think cases would be rare where transmissions, the advisability of which would be dictated by commercial consideration, would encounter serious difficulty from inductance and capacity. I have never personally investigated a proposed transmission of over 50 miles that gave any promise whatever of financial success, but the time may come when such a case will appear, and if it does, the work can be done successfully so far as the electrical part of the matter is concerned. I think the greatest difficulty in surmounting long distances is the difficulty of keeping a long line in proper repair. Eternal vigilance will be the price of success in this respect, otherwise there is little trouble. The apparatus is thoroughly reliable and efficient and the methods comparatively straightforward and simple.

Throughout this discussion I have taken the position that no one method of procedure is applicable to all cases. Personally I am decidedly eclectic in my taste, believing that it is better to put in for each individual case such apparatus as on the whole proves to be cheapest and best rather than to advocate, on any fine drawn theories, methods which might be applied to the perfectly general case of transmission of power. It is the concrete rather than the abstract that we have to consider when proposing apparatus on which the success of large commercial affairs depends, and although some methods are better than others, it is well to remember that while the electrical pharmacopoeia may have its calomel and paregoric it contains no elixir of life.

Remarks Concerning Power Transmission from the Economic Standpoint.

BY L. B STILLWELL.

At the Buffalo Convention of the National Electric Light Association, in February, 1892, in the general discussion of the subject of the electric transmission of power, a great deal was said about different systems of electric apparatus which might be employed for this purpose, and various opinions were expressed concerning volts, ampères, cycles, alternating versus direct current systems, and one-phase, two-phase or three-phase machinery. The subject appeared to be one of great interest to the convention, and the discussion was more or less instructive. But the writer carried away from that convention the impression that after all the manager or owner of a central station, or the business man desirous of securing information as to the practicability of profitable investment, must have failed to derive any great amount of information of the kind which he desired to obtain. The first question of such a man is, "Does it pay?" and it is a question which an engineer who has become so involved in the consideration of technical points as to lose sight of the question of practicability from a business standpoint has great difficulty in answering. But the business man is right. "Does it pay?" strikes direct at the root of the whole matter. The practicability of all systems and of all projects of this description must be measured in monetary units, and electric transmission of power, as well as every other form of engineering undertaking, must find its ultimate reason for existence in consideration of economy. Any engineering project which cannot live when measured by this standard should never be undertaken.

In discussing the subject briefly from an economic as distinguished from a technical standpoint, I wish to say at the outstart that I am aiming to obtain information rather than to impart it. The question which the practical man asks as to the economy of a project is the most difficult to answer. No answer that is perfectly general, and, at the same time, definite, accurate and infallible, can be made. The problem broadly considered is one of extreme complexity, comprising a large number of factors, and these are nearly all variable, whose actual values for any given case depend upon a variety of local conditions, the precise effect of which is not easily determined. Very few men, even among those who are actually operating central stations, are able to say exactly what power costs them, and it is not surprising that the engineer who is called upon to lay out, let us say, an elaborate plan for the utilization of water power, finds it difficult to give explicit answers to questions relating to the cost of operating such a plant, probable revenue to be derived from the sale of power, and, in general, economic feasibility. It is safe to say that no perfectly general solution of the economies of central station operation can be worked out. Time and the sure working of evolutionary law will some day clear away much that in the early days of a new business is inevitably more or less uncertain and speculative, but it is not to be expected that we shall even then be able to reduce these matters to fixed formulas. Of ten thousand plants the fittest will survive and pay dividends, and central station engineering will then consist of close study and careful analysis of the conditions, and methods which have led to the survival of these fittest installations. In other words, central station engineering will then be largely imitation.

At the present time we find in actual operation a large number of central stations utilizing the energy of coal by means of steam plants, and distributing power and light through the medium of various types of electrical apparatus. The number of central station plants operated by water power is, on the other hand, extremely limited. There is to-day, perhaps, no question of greater interest to owners and operators of central stations than that of the relative economy of transmission plants utilizing water power, and it will, therefore, be interesting to narrow the general problem of economics of central station operation in such a manner as to indicate how experience in the operation of the former class of plants may be made useful in predicting what will happen if water power be substituted for steam. The best way to arrive at results of some tangible value is obviously to compare a hydraulic and electric transmission plant with a central station using steam engines to drive dynamos.

In the former we have the steam plant, consisting of boilers, engines, pumps, heaters, etc.; the electric generating plant, comprising dynamos, exciters, and all electrical apparatus located in the central station; and the distributing plant, comprising motors, lamps, transformers, and the conductors connecting these with the central station. In the latter case it is usually convenient to locate a sub-station at a point adjacent to the market, for example, on the spot where the central station would be located were we to obtain power from coal. In such a plant we have the hydraulic apparatus, comprising dam, flumes, draft tubes, turbines, regulators, etc.; the electric generating plant, consisting of generators, exciters and all electrical apparatus located in the generating station; the transmission circuits between generating station and sub-station; electrical apparatus in the sub-station, which usually consists of transformers employed to reduce potential, together with switching and regulating apparatus; the motors, lamp and other translating devices in the local distributing circuits connecting those with the sub-station. We may assume that the two installations from the point where the local distributing circuits leave the generating station on the one hand and the sub-station on the other to the premises of the consumer are precisely similar. There is no reason why they may not be so, and since the whole installation, no matter which of the two alternative plans is adopted, must be designed to supply such service as the customer wants and will pay for, the assumption is perfectly fair. It follows that if the two contrasted plants are capable of delivering the same amount of power to the local distributing circuits they are alike as regards revenue. We may, therefore, at this point make our comparison still more direct by further narrowing the problem, disregarding the revenue side of the question and comparing simply annual charges. It is obvious also that it is unnecessary to compare annual charges upon that part of each of the contrasted plants which lies between the customer and the central station in the case of the steam plant, and between the customer and the sub-station in the case of the hydraulic and electric transmission plant. In other words, the phase of the general problem which I have selected as perhaps the most interesting may be stated as follows:

'What are the total annual charges against a hydraulic and electrical installation utilizing cheap power at 'A' and transmitting it to 'B' as compared with the annual charges against a steam and electric plant located at 'B' and capable of supplying the same amount of energy in equivalent form to the local distributing circuits?"

We may conveniently construct an algebraic skeleton or framework of the annual charges against each of these typical installations. When we come to translate algebra into arithmetic by substituting numerical figures for the algebraic symbols, opinions will differ widely as to the actual values of the different factors, but I think that the skeleton will be useful, as, by discussing and, if possible, fixing one factor at a time, we shall be better able to arrive at some approximation to a definite and tangible result. The method outlined in the skeleton framework is of course the method which a competent engineer who may be called upon to make estimates of the operating expenses of such plants will adopt; that is to say, he will naturally consider each item of expense separately, and make his calculations step by step. But the proper factors largely depend upon results of experience in the operation of plants sufficiently similar to make inference from one case to the other fairly safe, and accurate data relating to such experience are at the present time very difficult to obtain. My object, therefore, in this paper is to invite your attention to each of the various items of expense in such installations, to obtain information from your experience, and to suggest that it is in the power of the members of the National Electric Light Association to collect such a mass of data concerning the economics of central station operation and the distribution of energy for light and power purposes as will be of the utmost value in judging of the practicability of the thousands of projects of this description which will be under consideration within the next ten years. It is also in the power of this association to compare, analyze and arrange this information in such a way as to make the application to a new project direct and reasonably conclusive. If there be any means by which failure in ventures of the kind in which you are and will be interested may be avoided, we should certainly put ourselves in possession of those means as early as possible, and I would therefore respectfully urge the advisability of concerted action, looking to the collection and proper analysis of information concerning each of the various items of ex-

pense, and the various sources of revenue of your centra stations. The problem is somewhat complex, and unlessl we have some definite and progressive method of analysis it is practically impossible for an association which may be considering the subject, or even for a select committee of engineers who may be called upon to advise with reference to a specific case, to arrive at an agreement in which all will concur. I believe, therefore, that we may make good use of the skeleton statement of annual charges.

In calculating the annual charges against the steam and electric plant we must consider the following:

Fb—First cost of real estate and buildings.

Pb—Percentage, covering interest upon and maintenauce of real estate and buildings.

Cb—Constant expenses, taxes, insurance, etc., on real estate and buildings.

Fs—First cost of complete steam plant, including engines, boilers, steam pipes, pumps, heaters, etc, installed.

Ps—Percentage, covering interest upon and maintenance of steam plant.

A—Cost of fuel to produce one pound of steam.

S—Pounds of steam used per indicated horse power per hour.

N—Number of indicated horse power hours used per year.

Ws Cost of water (if any) per annum.

Os—Cost of oil and waste per annum for steam plant.

Fe—Cost of electric generating plant, including excit , regulators and complete station equipment.

Pe—Percentage covering interest upon and maintenance of electric generating plant.

Oe—Cost of oil and waste per annum for electric plant.

Cse—Constant expenses, including superintendence, wages, taxes, insurance, steam, etc., steam and electric plant.

Then: PbFb + PsFs + ASN + Ws + PeFe + Os + Cse + Oe = annual charges.

For the hydraulic and electric plant we have the following:

Fb—First cost of real estate and buildings.

Pb—Percentage covering interest upon and maintenance of real estate and buildings.

Cb—Constant expenses, taxes, insurance, etc., on real estate and buildings.

Fh—First cost of hydraulic plant, including turbines, dams, flumes, etc.

Ph—Percentage covering interest upon and maintenance of hydraulic plant.

Oh—Cost of oil and waste per annum for hydraulic plant.

Ch—Constant expenses, including superintendence, wages, taxes and insurance on hydraulic plant.

A—Cost of water per horse power hour (where water rate is paid).

N—Number of horse power hours at turbine used per year.

Fe—First cost of electric apparatus between turbine and local distributing circuits exclusive of line.

Pe—Percentage covering interest upon and maintenance of electric plant exclusive of line.

Oe—Cost of oil and waste per electric horse power from generators for electric plant.

Ce—Constant expenses, including superintendence, wages, taxes, insurance, etc., on electric plant.

Fl—First cost of pole line, insulators and conductors.

Pl—Percentage covering interest upon and maintenance of pole line, insulators and conductors

Cl—Constant line expenses (supervision and repairs).

Then: PbFb + Cb + PhFh + Oh + Ch + AN + PeFe + Oe + Ce + PlFl + Cl = annual charges.

And now, what have we accomplished? We certainly have not arrived at a definite solution of the problem of comparative annual charges; and the more carefully one looks at the statements, the more evident does it become that there are many factors the value of which can only be fixed by actual experience. It appears, however, that were we in possession of accurate and detailed data as to the cost, operating expenses and income of a steam and electric plant, we might form a pretty accurate idea of the practicability of an alternative project involving electric transmission of power. We should also need some information as to the cost of installing and operating hydraulic plants under various conditions, but this can be obtained with sufficient accuracy and with no great difficulty. The evolution of apparatus adapted to the efficient and reliable transmission of energy, and hence to the utilization of vast amounts of power in the form of falling water now wasted, has reached such a stage as makes this question a most vital one, and the importance of information relating to the cost of steam and electric plants now in operation is manifest.

This paper is offered simply in the way of suggestion and for the purpose of inviting criticism and comparison of opinions. The skeleton statements of annual charges have been hastily prepared and may doubtless be revised and amended with good results. It is intended simply for classifying purposes, to facilitate the accumulation of much needed data and to avoid confusion of ideas in discussion of the problem which I have attempted to analyze. I sincerely trust that the suggestion will be taken up by this association and effective steps taken to increase our fund of observed facts based upon experience, so rendering a most valuable service to engineering science and prompting the general welfare of all who are interested in the practical use of electricity.

DISCUSSION.

President Ayer: Gentlemen, you have listened to a series of papers pertinent to a topic that is fraught with interest to almost every central station man. The rapid development of our business brings forcibly to our minds the necessity of transmitting large amounts of power over long distances in large units, or on the other hand of maintaining central stations and smaller units. As our work in large cities accumulates, the proposition is presented to us that in the near future we shall have to add enormously to our station or generating capacity for the manifold uses of electricity.

To-day we are placed in a peculiar position. Our attention is called to the direct system, moderate sized units, covering a large area, which looks to be a very practicable method for many uses, and also to one very large unit, transmitting power to various centres of distribution and there distributing it, and a further suggestion comes to us, especially where we are located near our coalfields, of generating power at the mine and transmitting it to the various points of distribution; so that it may be wise to consider the advisability of one or the other of the multiphase systems that are offered. My experience is that the more we look into it the less we seem to know. The light that we are likely to get from the discussion of these papers certainly is something that we are all seeking. This is a very complex problem. I trust that you will all take hold of it with interest and draw out of these gentlemen as much as is possible in addition to and in explanation of their papers, remarks which will give us a clearer insight as to the best methods of proceeding in the future. Mr. Hammer, I would like to call on you to open the discussion.

Mr. Hammer: I have a few remarks to make on this subject, which is a pretty large one. Mr. Bell states that it is not practicable to use multiphase machines over 1,200 volts. I think there are machines, not very far from this city, running direct currents of 3,000 and more volts. Moreover, the other night Prof. Crocker made the statement that he had been running for some time direct current machines of 5,000 or 6,000 volts without any difficulty whatever. Mr. Bell has stated, in speaking of the three-phase system, that the current at one time was passing through one wire and returning through the other two. I think it is generally expressed the other way—that the one wire is the common return of the other two. I do not think he placed enough importance upon the application of the transformer in this country. I think it would be very interesting to all the station men here if Mr. Bradley, Dr. Bell and Mr. Stillwell and others would get up and state just why it is that the alternating motors of large capacity are not in use. I think an explicit statement of those gentlemen of exactly why that is not done would be interesting. I know they are used for fans, and everybody has an alternating motor that will be supplied in the spring or something of that kind. I think there is unquestionably an enormous field open for motors of that character, and if any one has such a motor which is practical there should be no hesitancy in bringing it forward. I would like to hear given a concise statement of just why these motors of larger power are not in use.

I would like to state that Mr. Bradley's paper interested me very much indeed. I think there are some excellent features and, in fact, a lot of meat in that paper. I think too that Mr. Stillwell's paper has a lot of good suggestions in it, and it is a paper which I should very much like to study. He stated in it that the Electric Light Association ought to take steps to collect data upon the subject he discussed, and my impression is that there is a Committee on Data for that very purpose. That committee should take it in hand. I think the idea an excellent one.

Dr. Bell: I shall be pleased to vouchsafe Mr. Hammer any information on the subject. In the first place as to high voltage: We know we can make an arc machine to work on high voltage. I practically stated in the paper that high voltage could be used requiring the employment of 1,200 volts or thereabouts if the machine is designed to carry large currents. Experience up to date has shown that they will not work satisfactorily for any length of time. Although very estimable gentlemen may think that they can build 5,000 and 6,000 volt machines for large currents, they had better build them for large currents before they brag much about them, for all machines which were built for large currents and high voltage have come to grief. Try to run on 50 or 100 amperes and there is trouble at once and immediately. I do not feel at all certain that we may not be able some day perhaps in another world to run direct currents perhaps 3,000 or 5,000 volts, but all our experience up to date has gone to show that when we have gotten a little above 1,000 volts we are in trouble so far as large powers are concerned, and I am not dealing here with matters of 50 or 60 or 70 h. p., which can be transmitted by a pair of arc machines. We are dealing with the question of handling large powers over long distances. Now inasmuch as direct current machines for large powers and high voltages have generally come to grief, I think we shall not be justified in saying that they are practical solutions of the question until some one shall have built a machine which both had a large current and high voltage and made it run with passable commercial success. The commutators on those machines are large and expensive, and I do not think that any one in this room is desperately in love with the commutator. The direct current at high voltage would be a very desirable thing for some purposes if we could get it, but what I mean to say is this, that we have not got it yet.

As to the point of the triphase current, I simply intended to convey the idea that there was a slight saving of copper. Inasmuch as the maximum of the three phases will not coincide, there is a certain amount of unused copper which becomes available which you get the advantage of.

As to the direct current transformer I am very far from desiring to belittle it. The transformer which takes a current at 1,000 or 2,000 volts and brings it down to 100 or 200 volts may have a very direct application after we get the high voltage machine. Transforming from 1,000 down to 100 or 110 volts is pretty small business compared with transforming from 10,000 to 100 volts. The triphase multiple transformer is very much more simple than the machine which takes a high voltage direct current and transforms it to a low voltage direct current. The winding is more simple and the machine itself is more efficient.

As to why alternating current motors in large sizes have not been used up to the present time, I think the principal reason is that there has been no very large call for long transmissions until quite recently. Apparatus does not spring up like crocuses in the spring; it comes after a demand for it has arisen; it is dragged out of the inventor's brain when commerce demands. And the reason why we have not had more of this long distance business is because we have not had any very large call for it. People go conservatively as people always go. It is perfectly practicable to run large synchronous motors; a matter about which there is no difficulty, and when occasion has arisen it has been done. A paper read not long ago before the American Institute of Electrical Engineers, I believe by my friend Mr. Scott (about which Mr. Stillwell knows much more than I do), covered that very ground of synchronous transmission. So my answer to that will be that as far as the demand has arisen for long transmission employing alternating currents they have been put in, and as that demand occurs they will continue to be put in.

Mr. Stillwell: As to Mr. Hammer's question as to why these motors are not used extensively at the present time, I think that Dr. Bell's answer is very true as far as it goes. The development of new apparatus generally awaits the demand for it. The last ten years have been filled, as far as the manufacturing companies are concerned, with a vast amount of work relating to lighting plants, and in the last three or four years all of the shops have been about as full as they well could be with railway work. At the same time the demand for this long range transmission has existed. The development in this country of the multiphase systems was taken up, as you know, by Mr. Tesla or rather it was taken up on the other side of the water, and he brought it to this country about 1888, or I do not know whether it was earlier in 1887, and he spent with others a great deal of time in working up the applications of this multiphase system, which opened the door to a type of alternating current motor which would start from rest and work with efficiency. He spent a great deal of time with a number of engineers in working up the very many details which must be worked up before such a system could be put upon the market. The problem of long distance transmission, when we consider it in connection with distribution from central stations, is far more complicated than any problem that has presented itself in the field of lighting or in the field of railway work. There are so many kinds of service which must be considered; it is an extremely broad engineering proposition, and it does not seem to me to be surprising that there has been a slow, but I think sure, evolution of the multiphase system as it now stands. I will say this; that within the last year there has been a great deal more activity than existed in the previous year or two. The last, or at least, one of the recent additions to the system, although the thing had been worked out before, a long time ago, is the rotary transformer. The application of that, as Mr. Hammer says, is certainly of the greatest value.

There is one point of a great deal of practical interest in regard to the difference between two-phase and three-phase machinery. As you know, Mr. Nikola Tesla is the inventor of the multiphase systems and after the study of that subject he very early invented the simplest and the most obvious arrangement, viz., the two-phase. Dr. Bell has stated his belief that the triphase has some advantage over the two-phase. There is one advantage of commercial importance, and that must be carefully considered, and that is the slight economy in the investment of copper. The triphase effects a reduction of about 14 per cent. in the amount of copper for the transmission circuits that would be needed by a two-phase system. Now that does not mean that we must increase our potential by any such amount as 14 per cent. in order to come back to even terms on the copper proposition. It is sufficient to go up about 7 or 8 per cent.; 7 per cent. would cover it unless I am mistaken. Seven per cent. increase of potential would bring the two-phase on all-fours with the three-phase on this point. And now as to the points on which the two-phase is distinctly and positively superior to the three-phase or any multiple system. The two-phase requires just two transformers at every point where the three-phase requires three. I think that, to a practical man, is sufficient to overrule all of the arguments in favor of the three-phase that have been advanced—assuming all of them to be correct. For a general transmission and distribution project, where we must supply power for lighting and street railway and general purposes, we must abandon the single phase; we must produce a difference of phase in some way, and having done that, we think it wise—at least it seems to me very desirable—to stop at the simplest form of the multiphase—that is, the two-phase apparatus.

Mr. Adams: It seems to me that the last question that Mr. Hammer asked on the floor was very important. While we may recognize and admit that we have not to-day large alternating systems of transmission, because there has not been much demand for machines of that

class, and transmission of that kind in this country, I do not see that we have an answer to the question, "Why we have not to-day, if it is possible to produce such a machine, an alternating current motor, in moderate sizes, which 'will fill,' to use a trite expression, 'a long felt want?'" That is a question I believe an answer to which would be very interesting to all present.

Mr. Hammer: I do not consider that Dr. Bell or Mr. Stillwell has answered the question I asked. Take, for instance, in St. Louis, there is a large alternating current station, and I cannot believe that an establishment of that kind would not be very glad to have a large number of 15 or 20 horse power motors to run elevators and things of that kind. If there is nothing in the way of their being supplied, they ought to get them. To dissipate my ignorance on this matter I want to know why they do not get those machines, and I would like to have Mr. Bradley enlighten us.

Mr. Bradley: I tried to build those motors, and have not been able to do it. We succeeded in building a motor to work on a single-phase alternating circuit which had an efficiency of 52 per cent., 1 to 2 h. p. We have never been able to construct one without a commutator, and wherever a commutator is used the sparking is something dreadful. If it is not bad when the motor is first started, after a few hours it becomes very bad, and we have not been able to design any brush that will obviate the difficulty.

Dr. Bell: I will simply add to Mr. Bradley's statement of the case what I have been able to get hold of regarding the Brown alternating motor, which has been exploited in Europe somewhat. The first efforts in the way of getting a motor to run on an ordinary alternating circuit, which would be self-starting, were made by Zipernowski and his associates; that started well, but, as Mr. Bradley stated, had a continuous blaze on the commutator during starting. That killed that motor dead. Now, since that time, Brown has been bringing before the public abroad two types of alternating current motor, both of which start fairly well, and are not in any marked degree open to that objection. One of them —one special type of them is, as I remarked before, practically the motor which Prof. Thompson showed at the Paris Exposition, and the other one is practically a Tesla motor, and those two motors have been exploited abroad. They run fairly well. They come up to speed and give, I should think, a very good efficiency. They, however, do not start well.

If Mr. Hammer meant to confine his question specifically, as I understand now he did, to the alternating current, single-phase motor, the reason why more of them have not been put out is that such motors, as a rule, do not start very well in small motors, fan size, and that sort of thing. They do start well enough for the purpose, and there are on the market fan motors that do very good service with work on alternating circuits. But the broad distinction between single-phase and multiphase motors is that the single-phase will not as yet start with sufficient facility to give them a good grip. That, I hope, will be overcome, as I stated in my paper, but at present we have not got it and the commercial demand has not brought it out. I have no grudge against the two-phase motor at all. And as far as the transformers go, it does not make any difference whether it is a multiple of two or multiple of three. In one case we have the same number of wires as in the other; in the three-phase we would only run three wires; in two-phase we run three or four; I think the usual practice tends more to four wires, so that I think the difference is quite largely constructional difference.

Prof. Weston: I think that Mr. Bradley hit the nail on the head a moment ago when he frankly admitted that he had tried to build an alternating motor of large power, but had been unable to do so. There can be no question as to the fact that there has been, and still is, a large demand for such a system of transmission of power as has been referred to, viz., a simple transmission by means of the ordinary alternating current generator. Therefore I do not think it is exactly fair to dodge the question. There has been a demand. The demand exists to-day. The difficulties have been so great that they have not been able to surmount them.

I would like to ask Dr. Bell why he makes the statement that 1,000 volts is the limit of work for the direct current, giving anything up to 100 amperes. I do not think that statement was well founded. I do not know whether Dr. Bell has any particular instance in mind; if so, I do not think the machine could have been designed correctly. I am quite sure of that, for with correctly designed machines I do not think there is any difficulty in running up to 5,000 volts, and with very large currents—very large currents, several hundred amperes. The question of the advantages of the two processes is still an unsettled one, and will not be settled, probably, for some years to come; it is a question of the survival of the fittest. But it does seem to me that the direct current system has a great many advantages over the alternating, and vice versa; just how the matter will terminate we shall have to wait, I think, to find out.

Mr. Bradley: I think this is a question of current; that is, as you increase the current you will have to decrease the voltage. It is not 1,000 volts, nor is it 1,200 volts, nor anything of that kind. With an arc machine having 9 or 10 amperes, you can readily reach 6,000 or 7,000 volts; with a machine having 20 amperes you can reach perhaps 5,000 or 6,000 volts. I do not mean to say this as a scale; I am merely trying to give an example of what the thing probably is. If it is 50 amperes the voltage has to be reduced. I think that is the explanation.

The President: We have among our members here Mr. Nunn, of Colorado, who has been operating a long distance plant with high voltages. I would like to hear from him.

Mr. Nunn: From experience in the back part of the room I am very much afraid I shall not make myself heard. I suppose my testimony in reference to the alternating plant that we have been operating is what is wanted. I can say that from its first installation to the present time it has been under my care, and I consider it a brilliant success, especially when I compare it with direct current systems which are in use around us. Our greatest trouble has been from lightning and from ground —ground very largely. The lightning has caused many defects and made many of the plants failures. It must be understood that we are in an unusual place. Our generating station was something over 10,000 feet high and our first motor installed was something over 12,000 feet high. We have made a run of forty-five days without discharging field of motor or generator. We have installed a 250-h. p. machine, and that is giving satisfaction so far. We do find a little trouble with some minor details, but they are purely a matter of mechanical construction of the machines and not a part of the electrical connections at all. Ours are of the synchronous type. We have to start our motors with a special starting apparatus, and we once in a while have a little trouble with that; that is, as far as the operation of starting is concerned, very simple. The men who take care of these machines, with two exceptions, are men who never saw an electric apparatus before. I think I have had sixteen different men in the last year and a half in attendance upon one motor, and without any exception these men have been able to take care of the motor without any trouble. I think this is a compliment, not so much to the sagacity of the men, who were simply Western miners, but to the simplicity of the system. It was a matter of considerable delicacy at first, and we were all very much afraid of ourselves; we can usually throw the machine together without a spark—without anything unusual. It makes a beautiful system. We have but two men at the generating station, working 12-hour shifts, and they control the speed for our five mills, and control it exactly, whether the motors are loaded fully or running light. The speed varies so little that it is one of the great beauties of our system. It must be understood that we use these motors in driving stamp mills in the reduction of gold ore, and perfect speed is a permanent requirement. I do not think that the time can ever come that in the electrical field can be found a system more beautifully applicable to these cases of long distance transmission in which large units (when I speak of large units I mean over 50 h. p.) are required at a constant and uniform speed on 365 days in the year.

Mr. Hine: My experience is entirely commercial. I am not an electrician nor an inventor. I think that there is a demand for a system, whether single-phase or multiphase, which can be used in cities like St. Louis for supplying power for all sorts of purposes—2 h. p. here, 2 h. p. there and 10 h. p. over there. I think it would be a great advantage if a central station man could be able to run the same generator and same system of circuit in a city like St. Louis. Long distance transmission is one thing; transmission of power for various purposes in a city is another thing. I think that all of the central station men here are looking very anxiously for the time when they can put in generators to run motors, some a quarter of a mile and some two miles from the station, any size, self-starting and that give no trouble. We are doing somewhat in that line, and have been operating motors for some time successfully under our own supervision. I regret very much that Mr. Stanley was unable to come here and take part in this discussion. He has been quite sick, and had to go South on account of his health. It seems to me that a distinction should be drawn between long distance transmission and distribution of the power from a single station in a city like St. Louis.

Dr. Kilbourne: I want to say in regard to the suggestion of Dr. Bell that I think it a good plan to put your transformers in large banks instead of putting a transformer in every building. We have a bank of transformers, and at night when our heavy load goes off we have our night watchman go along and throw off the switches of two transformers if we have three in the bank, and leave one to carry the load for the balance of the night.

Mr. Stillwell: I have just a word to say. It seems that Dr. Bell and I were under some misapprehension as to the extent of Mr. Hammer's question some time ago. I understood at the time that he referred to large motors, such as would be used in the transmission of power. I will make a distinction, as Ma. Hine pointed out, between transmission of power across country, whether that power is used afterward in small units or in large blocks, and the distribution of power in large cities from a central station to various small consumers. As to the non-existence of commercial motors to operate on the existing incandescent lighting circuits of alternating systems, I agree with Mr. Bradley that there are very great difficulties there which have entirely prevented, up to this time, the development of a commercially practical motor. It was this difficulty which forced Mr. Tesla to the invention of the two-phase system.

Mr. Hammer: I would like to have Prof. Forbes give us his experience with the two-phase against the three-phase system.

Prof. Forbes: I am very sorry, sir, but I hardly feel able just at this present moment to say much about the relative merits of the two systems. Of course I shall be having occasions to express my opinions on that subject pretty clearly in the course of the next week or two, and I think it would be hardly right for me to draw comparisons between the two at the present time. I am sorry that I have just missed the reading of this paper, which, I am sure, has been one of very great interest, and I know that I have lost a great treat by not hearing what Mr. Stillwell has had to say.

I can only say this in response to Mr. Hammer's kind invitation: that both the three-phase and the two-phase systems are working very satisfactorily in Europe. I have examined the apparatus and have made tests of the efficiency, and I feel confident that we shall get very good results from either of these two systems. Of course there are two problems totally distinct, as has been already mentioned—the question of transmission of power, and the question of distribution of power. They are two very different problems, and are capable of being treated in totally different ways. Of course, besides these two systems of transmission and distribution, for these are systems which are very applicable for distribution as well as transmission, we have also the single-phase system, which works remarkably well, and of which we have had considerable experience in this country as well as in Europe. I would mention particularly the installation at Telluride, Col. The only town in the world that I know at the present moment where alternating currents are used for distributing power is at Heilbron, Germany; but there may be others with which I am not acquainted; that, too, is on a very small scale; indeed, the amount of horse power distributed there is very small. This only shows that the objections which were originally raised against the alternating current for use as motive power have not been completely annihilated up to the present time, but that need not prevent those engineers who have the just consciousness of their views from proceeding to do large work with the alternating currents. In this respect I may perhaps be permitted to say a few words about the use of alternating currents with a single phase.

You can hardly go into the workshops of any manufacturer of any country, where there is originality of design, where the man at the head is a great thinker as well as a good mechanician—you can hardly enter the shops without seeing some motor work upon an alternating current of a single phase. I have seen at least a dozen classes of such motors, all working fairly well, but there are none of them being put at the present time largely on the market. I am speaking now of motors which will start from rest with a good powerful twist and which will keep up their speed and work economically. Of that type of motors I say I have seen a dozen different kinds in different workshops, but none of them largely used. I regret that I cannot make invidious comparisons between different systems just at the present moment.

President Ayer: This discussion has been exceedingly interesting and, I think, quite profitable to the membership. We have demonstrated one thing here to the central station man, viz., that our American electricians have very little faith in the promise or in the probability of the development of a practical alternating current motor for the single-phase current. We have had large experience; Mr. Bradley relates some of his in this country and Prof. Forbes has given us his observations abroad, to the effect that many of the shops have in operation various types of motors of small horse power—one and two and more—operating fairly well, doing some work and indicative of great promise; and possibly when the heads of the concern are consulted and some attention is called to these motors, they do not like to admit that they are a failure. Certainly the evidence is that our various manufacturers and representative men have pretty well concluded that there is little to be gained from them. This is a disappointment to many of us. We have been anxiously awaiting this motor, and it is hard to give it up; but with the experience of the past and in view of the opinions we have heard expressed today, I do not think that any of us will lay our plans for utilizing motors of this character in the near future. The points brought out are the points that are of value to us central station managers. These are the net results that we were after. As I said previously to opening this discussion, the rapid development of the business makes a demand on us for judging what methods must

be adopted to provide for the future, and the question is forced upon us for immediate action. We are either turned back to our direct current motors for power, where it is to be utilized in varying units, such as are demanded of us for commercial wants to-day, or else we have to look forward to the development and introduction in the near future of the multiphase motor. We all hope that that time will be hastened so that we may be able finally to decide the problem, because long distance transmission of power goes, and must go, hand in hand with the distribution of power.

Prof. Forbes: I do not wish a misapprehension to go abroad as to my meaning in what I said about these alternating motors on a single phase. I am referring, when I speak hopefully of what I have seen, to a transmission of power—essentially of power—in which we are at liberty to reduce the frequency of alternations very considerably.

President Ayer: In speaking of the application or the probability of the early development of a motor for use on our present lines, I referred to the apparatus we have in service—the high frequency apparatus which is utilized in this country, 16,000 alternations per minute; and I am very happy to know that you agree with the opinions expressed here—not that I am happy to know that we cannot get that motor, but that the opinion is unanimous.

The "Vulcanizing" Process for Preserving and Strengthening Poles, Cross Arms, Ties, Etc.

BY HARRY C MYERS.

When we consider that the annual consumption of timber in this country equals twice the amount of material supplied by the annual growth of our forests, it is apparent that the subject of wood preservation, wood strengthening and the utilizing of certain woods now considered as worthless is a most important and vital one.

Wood as it occurs in nature consists of cellulose impregnated with resin, volatile oils, sugar, gum, tannin, protein bodies and the usual mineral constituents of plants. The percentage of these various constituents, of course, depends not only upon the kind of wood, but upon the season of year, locality, nature of the soil, and part of the tree from which any given sample is taken, hence any results or tests would be only approximate ones.

When wood is heated, as in ordinary wood distillation, the cellulose decomposes and a chemical change takes place between it and the natural constituents of the sap, resulting in a most powerful antiseptic mixture containing acetic acid, methyl alcohol, acetone, methyl acetate, tarry matter containing phenol, creosote, carbolic acid and about thirty other chemicals of lesser practical importance.

The following percentages by weight were distilled from various woods:

Yellow pine	57.8 per cent.
Norway pine	56.8 per cent.
Virginia pine	60.2 per cent. to 72.1 per cent.
Red oak	55.3 per cent.
Spruce	58.7 per cent.
White pine	61.2 per cent.
Poplar	59.0 per cent.
Cypress	59.0 per cent.

It must be borne in mind that these chemicals and antiseptics result from the action of heat on the natural sap of the wood, and are entirely different from the original sap, which allows of the attacks of microscopic fungi and decay. Why has it occurred to no one to heat timber to a temperature which would produce the above change, and then to keep the changed antiseptic mixture there under pressure, instead of distilling it out of the wood? Such is the entirely new and original process known as "wood vulcanizing," viz., the heating of wood and timber under great pressure.

Hundreds of processes for preserving wood have been patented, and all of them may be divided into two classes: 1. Those in which wood is impregnated with a preservative material by immersion. 2. Those in which a preservative agent is forced into the pores of the wood. Such chemicals as copper sulphate, zinc chloride, mercuric chloride, dead oil, etc., have been applied, but experience and results have failed to prove them all that is to be desired in an economic and effective means of wood preserving. The poisonous nature of such chemicals makes the application and use of them very objectionable.

In the process of "vulcanizing," wood is heated in closed cylinders from eight to twelve hours at a temperature ranging from 300 degrees to 500 degrees Fahrenheit, and under a pressure of from 150 to 200 pounds to the square inch. A circulation of superheated and dried compressed air removes the surface moisture and any water that does not take part in the reaction and combine with the woody constituents. Hence, wood or timber, in any condition, may be immediately treated. These cylinders for the treatment are 105 feet long, 6½ feet in diameter and are made of steel. As the treatment penetrates to the heart of the timber, considerable time is required for cooling, which is, of course, done in the cylinder and under pressure. Timber is introduced and treated upon cars which run into the cylinder upon small tracks. The percentage of dark antiseptic matter contained in vulcanized wood, I find to be as follows:

Vulcanized yellow pine	55.3 per cent.
Vulcanized Norway pine	56.7 per cent.
Vulcanized Virginia pine	58.9 per cent.
Vulcanized red oak	54.0 per cent.
Vulcanized spruce	57.9 per cent.
Vulcanized white pine	55.5 per cent.
Vulcanized poplar	59.0 per cent.
Vulcanized cypress	56.8 per cent.

The samples from which these results were obtained were companion pieces to those from which the previous results were obtained; a comparison shows the percentage of moisture removed by the vulcanizing process.

This process apparently makes decay impossible by sealing up the pores of the wood with antiseptic matter which becomes solid and firm on cooling and standing, and which is produced within the wood by the action of heat and pressure upon its original sap.

The original sap is colorless or pale yellow, and the changed sap very dark or black, hence a most desirable dark antique color may be imparted to oak and other woods.

The following tests were made at the School of Mines, Columbia College, by request of the Western Union Telegraph Company, upon cross arms to be used on telegraph poles.

In each case two cross arms were made from the same piece of timber, one was vulcanized and the other left untreated. Results give, in pounds, the weight required to break each cross arm:

Vulcanized Norway pine	3,000 pounds
Natural Norway pine	2,680 pounds
Vulcanized cypress	2,600 pounds
Natural cypress	1,800 pounds
Vulcanized spruce	2,785 pounds
Natural spruce	2,460 pounds
Vulcanized poplar	3,840 pounds
Natural poplar	2,560 pounds

These startling results show an average increase in strength of 18.9 per cent. Similar tests, made by Prof. R. H. Thurston and Prof. Alfred Trautwine, of Stevens Institute, verify the above results.

The Hon. B. F. Tracy, Secretary of the United States Navy, with a view of adopting vulcanized wood in naval construction, appointed a committee, who visited the vulcanizing works in New York City, made tests of their own on yellow pine, showing an average increase in strength of 18 per cent. and a decrease in deflection of over 13 per cent.; hence they reported that vulcanizing increases the durability and strength of timber, and recommended such timber for use as backing in one of the monitors.

Untreated cross arms, which had been painted and used by the Bell Telephone Company for from two to three years, showed, by actual test, an average decrease in strength by exposure of 18.78 per cent., as compared to new untreated cross arms. Other pine cross arms which had been in service on Western Union telegraph poles for three years and over showed an average loss in strength by exposure of 38.12 per cent. The process of vulcanizing seasons all timber, thoroughly preventing any further warping, checking or cracking. Such timber is not influenced by atmospheric agencies, bacteria or spores, and requires no paint for protection, as it is saturated with antiseptic preserving material of its own; the albuminous constituents of the natural wood have been coagulated by the high heating and rendered insoluble.

Loblolly pine, as it is used in the South, decays in about three years, and is unfit for any railroad construction where it is exposed to the elements. This timber when vulcanized is as durable as ordinary timber and ties used in railway construction. Other woods are seasoned and rendered beautiful by vulcanizing, which produces very desirable colors for interior decoration.

The life of vulcanized timber is not known; none of the timber or ties used in railway construction during the past ten years have been known to decay. I personally examined some 12×12 pine timber which had been placed in a machine shop in 1882, part being vulcanized and part untreated. The treated timber is perfectly sound and still in use, while the untreated had completely rotted and crumbled away after five years' use. I also find by personal investigation that timber placed on the Manhattan Elevated Roads of New York City as far back as 1883 shows no signs of decay, and is as sound and sweet as if fresh from the tree, while untreated timber laid at the same time has rotted away and been replaced.

As vulcanizing changes the sap from the liquid to the solid or semi-solid state, does not char or make the wood brittle, saturates and seals up the pores of timber with solid matter instead of liquid soluble matter which nature provides, considerable strength and durability are added by vulcanizing, the wood being rendered more cohesive, harder and denser. The spike holding quality is naturally much increased, and even after ten years' service railroad spikes seem to be as firmly imbedded as when just driven.

It is also a curious fact that the electrical resistance of most woods is very greatly increased by vulcanizing.

Underground Conduits and Conductors and the Experiences of Electric Lighting Companies of New York City.

BY WM. H. BROWNE.

Those who are intimately acquainted with the histories of the electric lighting companies of New York City may be pardoned if they believe that the experiences undergone by those companies have been unique, and that they afford to companies elsewhere opportunities for beneficial consideration.

At the risk of presenting some incidents having the aroma of antiquity or being tedious by the recital of what may perhaps now be considered well-worn tales, attention is invited to a statement, as brief as possible, of the story of electric lighting in New York City, from the beginning to the present time.

In the years 1880 and 1881, but twelve or thirteen years ago, two companies began in New York City the business of distributing electric current from central stations for public and private illumination, the one using the Brush, the other the United States, system of arc lighting.

They were the pioneers, at least in that city, in the business of electric lighting. They were provided with apparatus which, compared with present standards, would be considered totally inadequate to the designed purpose. They were obliged to undertake the operation of such apparatus with employés who were necessarily ignorant of its construction and methods of use. They had also to encounter an atmosphere of mystery in which the electrical business seemed to be enveloped, and which was intensified by the pernicious ideas of those who had learned, or believed they had attained some knowledge of it, that their personal advantage and preferment were obtainable only by secluding to themselves such information as they believed they had acquired. In brief, these companies experienced to the utmost all the trials and difficulties belonging to those who begin in new and untried fields.

Coincident with this imperfect apparatus and the other difficulties alluded to, the best medium then obtainable for the transmission of current of high potential was bare wire.

Contrast that means of transmission with what is now deemed requisite.

The first step from that bare wire toward the underground conductors of to-day was soon found necessary.

That necessity developed the cotton-covered wire, and with that the operatives felt safe from injury by shock.

Soon some protection from the conveyance of fire by the covering became necessary, and then followed the saturation of the cotton covering with lead. This proved so equal to the conditions that the fire underwriters in the interests of insurance companies formulated rules prohibiting the use of any other but that wire, which obtained their own name of "Underwriters."

With this progress in the improvement of the conductor, improvements in the apparatus and appliances brought them to such a condition that, coupled with the knowledge acquired by the operatives in the handling of them, and the most scrupulous supervisory control of the lines, it became possible to pass through one entire night occasionally without having lights out or a "dead ground," or "short circuits," and that was a night to be inscribed upon the archives of the companies as an occasion from which to date progress toward the next improvement.

It will no doubt seem, to many of you who have not had personal acquaintance with similar conditions, incredible that capital could have been invested and efforts exploited in a business conditioned as this was in those days; but the above statements are merely the baldest facts, and could be amplified by numerous incidents in testimony of their strict accuracy.

However, the companies struggled with the conditions; they sought and used all the improvements obtainable, and finally were able to give tolerably consecutive service with the result that a few customers began to use the light and were willing to pay a fair price for it, 75 cents to $1 per light per night.

But the extension of the use of electric illumination was not so rapid or so widespread as to call for many wires or very large poles. The operators of the company had not had such strong pecuniary inducements as to justify them in being very enthusiastic in looking to the possibilities of the future.

They felt justified in restricting their efforts to satisfy such demands as were made upon them, and, whenever a customer was obtained beyond the limits of the wires already erected, the lines were extended with the least possible expense

The poles used were ordinarily 6 to 8 inches in diameter at the base, and 20 to 25 feet high, provided usually with a four-pin cross-arm A few of these poles have remained and are in existence at the present day.

In the year 1884 manufacturers of other apparatus saw in New York City a field of profit and advancement for their machinery. New York was the largest and richest city of the United States; the companies then doing business in that city were actually on the verge of paying dividends; and it could not be considered proper in the interests of the public that they should continue to have a monopoly; investors were sought and assistance obtained toward the creation of other companies who would utilize their apparatus, and reap great profit in the furnishing of electric light to the citizens of that great city. The result was that in the year 1884 franchises were granted to no less than six other companies, all of them primarily intended for arc lighting. Some of these companies, taking note of the numerous poles that were in existence for the telegraph, telephone, police and fire department service, deemed it uneconomical to erect poles for their own wires, but arranged with those having charge of such poles for the attachment of the electric light conductors on those existing poles. Some of the companies created in that year did not make rapid progress, and the increase of poles and wires for electric lighting was not materially appreciable until 1888.

During those years, however, the wires for telegraph, telephone, messenger service, police and fire alarm had increased rapidly and become so numerous and filled the air with so many strings of iron that the public became offended and bills were introduced in the State legislature looking to the burial of those wires. The electric light wires were so few as to be scarcely noticeable and did not attract attention.

In 1884 a bill was passed in the legislature directing that the wires be removed from the streets before the first day of November, 1885, but it provided no means to insure their removal, nor penalties for non-removal. The legislature of 1885 having found that the previous enactment had accomplished nothing, passed another act which provided "that if no suitable plan should be proposed for placing the said wires under ground, it should be the duty of the said Board of Commissioners to be caused to be devised and made ready for use such a general plan as would meet the requirements of the said acts of 1884–5, and that the said board should have full authority to compel all companies to use the subways prepared." Under this act the Subway Commissioners, who had not been provided by the act with funds wherewith to carry out the object named in the act, deemed it wise, in order to carry out the purpose of the enactment, to make a contract with some company to build the subways, and did make such contract in 1886.

Persons interested in the telephone company realized that the purpose of the act would inevitably be carried out; and as the interest of that company in the fulfillment of such purpose would be affected to a greater extent than any other, except possibly the telegraph company, they deemed it prudent to become interested in the company with whom the Subway Commissioners had made the contract for the construction of subways. This secured to the telephone company a right of way of almost incalculable value. Even at that time the place and method of the burial of electric light wires were scarcely considered. Some approaches were made to the two old companies engaged in electric lighting, as to their taking upon themselves the task of building subways for electric lighting purposes, but they, it appears, chose to refuse to entertain the proposition. If they had decided as did the telephone company it is very probable a different condition would now exist in the electric lighting business in New York City.

In 1888 began the introduction of the alternating system of incandescent lighting. Until that year electric lighting had been confined almost exclusively (of course, outside of the low tension company) to arc lighting; and the increase in the business to that time had not required the multiplication of wires and poles to any considerable extent. In 1888, however, four companies began a spirited effort for the introduction of incandescent lighting, with the result of contracting for upward of 60,000 lights within less than a year. This caused a considerable increase of wires. The wires were strung principally upon the poles previously in use. Comparatively few new poles were erected, until in the latter part of 1888 the Board of Electrical Control, recognizing the increase of electric lighting, formulated rules for the extension of that business by means of overhead construction, and in order to provide the best possible overhead construction prescribed certain requirements in which, with the immediate supervision of the Board of Electrical Control,

what has probably been the finest line in the world was erected. It was considered an ideal line. It consisted of poles 85 feet high, 16 to 18 inches diameter at the base, and not less than 8 inches at the top. On this line were strung something like 150 wires, none less than No. 4—the majority No. 2. The poles were made tall so that the wires might not interfere with the operation of the Fire Department; and if breaks should occur between poles the wire could not reach pedestrians, and also to avoid the numerous crosses with the other wires which were the source of much trouble. To further secure these results the cross-arms were placed at the highest part of the poles. Experience soon suggested that this mass of weight must be removed from the top, and they were carried down some 15 to 20 feet. This precaution was, however, not sufficient, as in December, 1891, a section of that line, about a mile in length, fell into the street.

During 1888 the companies having aerial lines in upper Broadway, the principal thoroughfare of the city, were directed to place cables in the conduits, which had been prepared in the street, and to remove their overhead construction.

But the companies objected strenuously.

They declared vigorously that it would be impossible to operate currents of high tension under ground.

They were supported in this contention by professors and others learned in the art.

They appealed to the court to be sustained in this position.

The then Mayor of the city, also, by virtue of his office, President of the Board of Electrical Control, agreed substantially with the companies, and opposed his fellow members.

The controversy became heated and to a certain extent personal. In fact so much so that the Mayor refused to sit with the other members of the Board of Electrical Control.

The courts declared that the law gave to the Board of Electrical Control the power and the right to decide whether the subways were fit and proper for the purpose, and ruled that the companies must comply with the law and occupy the subways with their cables and remove their overhead construction.

In August, 1888, the first effort was made to use electric light subways on Broadway, from Fourteenth to Thirty-fifth street. The subway company had invited the companies to make the experiment of operating high tension currents under ground, and offered the use of the subways without rental for the experiment. The first cable was placed for arc service, and consisted of eight conductors, insulated from each other and inclosed in lead armor. The experiment with this was not successful. The cable did not meet the requirement of the Board of Electrical Control of an insulation resistance of 15 megohms per mile for each 100 volts for each conductor. This result seemed to verify the claims of the companies that arc lights could not be served from underground conductors under the conditions imposed and existing.

The opposite view was maintained, however, by the Board of Electrical Control and its contractor company; and the courts having held that the law accepted no other decision than the opinion of the board, the companies were threatened with the removal of their aerial wires in the localities provided with subways, whether they placed cables in the conduits or not.

The year of 1890 brought a new Mayor and President of the Board of Electrical Control. He immediately promulgated the order that within 90 days the wires must be removed by the companies from streets provided with subways or he would exercise the right given by the law to have them removed by the city.

At that time two other companies undertook to make a test, one to the extent of one block on 125th street, the other of a circuit of 21 blocks on Broadway and Sixth avenue for 10 arc lights.

Controversies and contentions between the companies and the authorities had become so animated that the companies were not credited by the authorities with being disposed to have the experiment succeed; and although they laid their cables with all attainable speed, and were successful in the tests and announced their intention to occupy the subways as rapidly as they could, no extension of the 90 days' time was granted, but on the fifth day of April, 1889, the authorities began the cutting down of the electric light aerial lines on Broadway and Sixth avenue, where the subways had been provided.

This action aroused great excitement in the public mind, and the authorities were applauded by the newspapers for their vigor. The occurrence of several accidents, principally to employés, working on overhead lines, aided by sensational articles in the newspapers, increased the excitement so that the Board of Electrical Control, who in the preceding year had devised the rules under which the large line heretofore referred to was erected, and who had supervised its construction, and believed that by it they had found a way to provide for the extension of electric lighting and carry out the provisions of the law under which they were established, without excessive construction of subways, objected wholly to the use of aerial lines for electric lighting purposes, with the result that in October, 1889, they declared destruction practically to all the lines in the city except the one built under their guidance the year before, and ordered the construction of subways with what can now be undoubtedly considered erroneous judgment and with undue precipitation.

Concert of action between the authorities and the companies, careful deliberation of the probable requirements and the energy which makes haste slowly but correctly, would not have produced, it is true, the removal of the overhead lines to the extent that was accomplished in practically two years; but also it would not have produced the extraordinary expenditure of money both by the subway company and the electric lighting companies, nor the loss of business and disturbance that occurred to the companies; but it is fair to presume that a somewhat different condition of the subway situation and of the electric light companies would have been effected with material benefits to all financially interested.

There have been built for high tension electric lighting 600 miles of ducts; of this about 260 miles or 42 per cent. rented by the companies. Included in the amount stated as rented by the companies are about 50 miles not occupied yet with cables. These ducts so rented and not occupied are the result of a rule passed by the Board of Electrical Control in 1890, in deference to the wish of the Department of Public Works, that wherever streets were to be repaved subways must be built previous to the paving or they would not thereafter be allowed, and companies failing to make application for conduits in such streets at that time would be deprived forever after of the opportunity of obtaining accommodations in those streets for the transaction of their business. They were further required, in making application for such accommodation, to give a bond securing the occupancy of, and payment of rental for, such ducts as were so constructed for five years from the date of completion. This rule was subsequently enacted into a law by the Legislature. Under that rule the companies applied for the construction of subways in anticipation of the future, and not for immediate need.

At the present time, there are, therefore, occupied with cables only about one-third of the ducts built. Instances of subways built in excess of requirements, as developed to the present date, may be noted. On Broadway there are 200 miles of ducts, of which but 80 miles are occupied. On Third avenue 142 miles, but 41 miles occupied; on Twenty-third street 34 miles built, 11 miles occupied; on Twenty-ninth street, 28 miles built, 17 miles occupied. It may be considered a very reasonable calculation that the increase in the occupation of subways on those streets will never require all the ducts built.

The 600 miles of ducts occupy only 78 miles of streets. The number of miles of ducts, therefore, in any street occupied with cables averages less than three miles. With the 600 miles of ducts now built distributed in this ratio, nearly 200 miles of streets would be provided with subway accommodation, and the extent of the territory available for the development of the business enlarged to three times its present area. Of the 600 miles of ducts, 454 miles were built prior to the year 1890, and included in that construction were the streets above recited, in which continue to be so large a number still unoccupied.

During the last year, 1892, 24 miles of ducts were built, occupying nearly 10½ miles of streets, or an average of two ducts per street.

If the work could be begun now in the light of present experience, the average number of ducts per mile of street would not probably exceed three. For all kinds of service one duct will provide ample accommodation in the greater portion of the city.

The 200 miles of ducts occupied with cables are confined to the 78 miles of streets, and contain for main cables about 600 miles, or nearly eight miles of cable per mile of street, and an average of three cables per mile of duct occupied. About 320 miles are used for arc circuits, and 280 miles for incandescent circuits.

These cables represent in many instances the occupation of a given street of ducts by each of four separate groups of companies, all seeking business, and having customers in the same street and often in the same block.

But for this quadruplication of occupancy the mileage of cables at present in use would provide a current in a much greater mileage of streets, and to a larger number of customers.

The cables are divided into 81 circuits for arc lighting and 50 circuits for incandescent lighting, all the latter being used for the alternating system. One of the arc circuits is about 15 miles in length, several are about 12 miles long, 18 are longer than 8 miles each, and 40 over 5 miles; the average, however, being less than 4 miles. The incandescent circuits average over 5½ miles each.

Connecting these main cables with the premises of customers through the subsidiary subway connections are about 150 miles of cables, so that the aggregate mileage of cables underground is about 750.

The 81 arc light circuits supply about 5,000 arc lights, or an average of about 60 lights per circuit, and an average of about 15 arc lights per mile of cable.

The incandescent circuits supply about 90,000 incandescent lights, or an average of about 1,800 lights per circuit, or about 320 lights per mile of cable.

In the operation of these 750 miles of cable there have been manifested during 1892 faults of all kinds to the number of 49. Faults are reported to the subway company as soon as discovered. As access to the ducts cannot be had except under the supervision of the employés of the subway company it must be assumed that all faults discovered are reported. Faults are classified under three heads: "Low tests," "grounds" and "burn-outs."

"Low tests" are discovered in the tests which are required weekly of every circuit and mean that the insulation resistance of the cables has fallen below the minimum of five megohms per 100 volts per mile, below which it is not permitted to operate a circuit until the fault has been ascertained and remedied. The number of "low tests" for the year were five on arc and six on incandescent circuits. The "low tests" were discovered to be in the terminals, one being on an arc, the other on an incandescent circuit. The cause of three "low tests," one on an arc and two on incandescent circuits, was not ascertained. Three "low tests" on arc and three on incandescent circuits were discovered to be due to bad joints.

"Grounds" were discovered 16 times on arc and eight times on incandescent circuits; eight of the "grounds" on arc and one on incandescent circuits were discovered to be in the terminals. The cause of three "grounds" on arc and one incandescent circuits is unknown. Two "grounds" each on arc and incandescent circuits were ascertained to be due to mechanical injury to the cables, and three "grounds" on arc and four on incandescent circuits were discovered to be due to bad joints.

Eleven "burn-outs" occurred on arc and three on incandescent circuits; three of the burn-outs on arc circuits were due to causes not ascertained. Three "burn-outs" on arc and three on incandescent circuits were ascertained to be due to mechanical injury of the cables, and four "burn-outs" on arc circuits were ascertained to be due to bad joints.

Two "low tests" and nine "grounds" due to terminals cannot be considered as faults in the cables proper. Of the 38 faults discovered in the cables 18 were due to bad joints, 10 to mechanical injuries, and 10 to causes unknown; but probably mechanical injury.

The 38 faults of the cables occurred on 25 circuits, so that 106 circuits were operated throughout the entire year without a fault or trouble of any kind. Two of the 25 circuits were each responsible for five of the faults, one having four "burn-outs" and one "ground," the other four "grounds" and one "low test."

It may be said here that the troubles from bad joints occurred usually at the beginning of the use of the circuit, and the same may be said to a large extent of the troubles with the terminals. This can be avoided by careful work.

The nine "burn-outs," eight "grounds" and three "low tests" due to mechanical injuries or causes unascertained may be considered as the dangers which cannot be guarded against in a system where cables of several companies are in the same manhole to which employés of each have access, but the experience of nearly four years indicates that this source of trouble is decreasing. From May, 1887, to March, 1889, twelve explosions occurred in the subways; since the latter date none has occurred. No one has been injured from any cause.

Most, if not all, the incandescent circuits are operated every hour of the day, and some of the arc circuits also. Tests are usually made with all connections undisturbed.

Customers, for incandescent lighting especially, have come to expect the light to be ready for them whenever they call upon it, and to be uninterrupted and of high standard. The above record of faults or troubles with the cables indicates that they may rely upon such service, and the occupation of the member of the staff of an electric lighting station known as "trouble hunter" has passed away.

Nearly all the current for the high tension arc and incandescent service transmitted in the city of New York below the Harlem River is conveyed by underground cables. Above the Harlem River the Board of Electrical Control allows the construction of aerial lines, no subways having been built in that section of the city. Below the Harlem River no overhead wires are permitted to be erected and few of these that were in existence remain. It is probable that before the end of this year scarcely any will be in existence. The penalties endured by the companies for their opposition to the subways have been severe and drastic. The expense imposed upon them in their effort to take care of their business and meet the requirements of transferring their systems from overhead to underground has been enormous and burdensome. The expenses continuing for rentals, due in a large measure to the amount of subways constructed and not occupied, continues and seems likely to continue to be an onerous tax. These expenses and burdens have tended and are likely to tend further in the future to confine the operations of the companies to territory contiguous to their generating stations, and may also tend to avoid the fierce competition which existed during the days of aerial transmission, and which lowered prices to a point below remunerative rates.

If the subway situation in New York City was not such as it is, and it is such from the causes above suggested, there seems no reasonable doubt, in the light of the experience possessed by all conversant with the situation, that fully as satisfactory accommodations and results could be accomplished at not exceeding 25 per cent. of what it has cost, and with corresponding beneficial conditions which would prove at least not unremunerative to all interests affected.

From the experience of electric lighting companies of New York City in their early days to that of their present practically uninterrupted service is a vast step in advance in operation. The business of the generation and transmission of electric currents for all purposes to which it is applicable is no longer in the tentative condition of those early days. There is no longer any reason for beginning a company without full conception of what it may be expected to do. Competent engineers and electricians are many, who know the exact relations necessary between the several parts of a central station and its output. They are competent to plan the exact conditions needed between the boilers, engines, generators and constructors. With the use of electricity for power for street cars and mechanical requirements conductors will be multiplied

May it not be concluded, in view of the experiences in New York City, that all aerial conductors are necessarily transitory, particularly in our large cities?

Is it not advisable for controllers or managers of companies in such places to recognize that condition, and endeavor to avoid the experiences of New York companies by planning deliberately the procurement of the right to themselves to build and operate their own subways, and, further, to utilize the experiences of New York to avoid the expensive mistakes there made, and to place their business on a stable footing and in a position where they may have immunity from injurious and cheap competition, and secure service to their customers free from the interruption belonging to aerial transmission? It is rumored that one company in a large city, where no laws compel them to do their business underground, feel themselves forced to seek that method of doing their business, by reason of the fact that their aerial lines are being overloaded. Is this not likely to be the case in many other places? The telephone companies find it materially to their advantage to use underground conductors, and are doing it in many cities.

Underground conduits and conductors for electric lighting and power provided with due care and deliberation need not increase the fixed charges of companies doing a reasonable amount of business to such an extent as to be prohibitory.

The transmission of electric current is entirely analogous to that of gas, water or steam, and must inevitably, in the not very distant future, be conducted underground, as they are. To electric light companies, as to gas, water and steam companies, the legislatures and law-making bodies should give rights enabling them to meet the condition in the manner calculated to produce the best results for the companies and the public users, and if the above recital of causes and effects, experiences and results in New York City will tend to prepare the way to avoid, to other companies, the experiences of those in New York City, the relator will feel justified with his effort, as he is appreciative of the compliment implied by the invitation of our worthy president which has afforded the opportunity to offer it for your consideration.

The Incandescent Lamp from a Commercial Standpoint.

BY CALVERT TOWNLEY.

All modern commercial forms of electric incandescent lamps in this country are similar in that each produces light by heating to incandescence a hard carbon burner of comparatively high resistance, inclosed in a glass receiver from which the oxygen has been largely exhausted. We know that after a time a burner so heated gradually depreciates, either by disintegration, oxidation, or some other cause, and is finally destroyed. We know that, of two similar burners, that raised to the higher temperature will require less energy per unit of light produced, but that its depreciation will also be more rapid and its destruction take place sooner. Consequently, in determining the temperature at which a carbon should be burned to secure the best economy, we are influenced to use a high temperature on account of the first condition, and a low temperature on account of the second condition.

There may be said to be other causes, due to differences in the design and construction of various lamps, which will affect the length of the lives of their burners, but it seems fair to assume that, by the employment of proper methods, these causes may be eliminated in so far as they hasten depreciation in one carbon more than in another, and therefore, in discussing the relation be-

tween the life and efficiency of different lamps, we may consider simply the characteristics of their burners.

For convenience in discussion, we may divide the commercial lamp burners into three classes, viz.:

1st. The untreated or natural burners used in the Edison lamps.

2d. The treated or flashed burners used in the Sawyer-Man, Thomson-Houston, Beacon and a number of other lamps.

3d. What we may call the super-treated burners used in the new Westinghouse stopper lamps.

In all published tests of the life of burners there is shown to be a definite relation existing between the life of a carbon and the temperature at which it is burned, this relation remaining fixed for carbons of the same kind and varying only for carbons of different kinds. If we formulate this relation, it will assist us to determine what temperature of any kind of carbon may be expected to yield the best commercial results; that is to say, how much money it is desirable to spend on the maintenance of the carbon, and how much on the energy to heat it. The temperature of a burner is difficult of measurement. It will, therefore, be simpler, and quite as satisfactory, if we consider the relation between life and energy consumed, expressing the latter in watts.

By a series of experiments extending over several years and covering tests of many thousand lamps, Mr. Frank Stuart Smith has found the relation between the life and efficiency of the Sawyer-Man carbons, and through his courtesy I am permitted to give you the results. The relation is expressed by the curve A, illustrated herewith in Plate I., where the axis of Y represents hours life, and the axis of X watts per each candle of light produced. As this relation is confirmed by so many tests made at different times, upon lamps of different efficiencies, and under the care of different assistants, there can be no reasonable doubt as to its correctness. From a limited number of experiments made on many other lamps having treated carbons, it is indicated, as might be expected, that the relation between the lives and efficiencies of their burners follow the same general law. Therefore, if we assume that these lamps are constructed with the same detailed attention to design and manufacture, we may then also assume that their curves will not vary materially from that of the Sawyer-Man carbon.

The exact mathematical expression corresponding to this curve is somewhat complicated, but, as we are considering the question from a purely commercial standpoint, we may consider the curve between commercial limits, in which case we can express the relation within one-half of one per cent. by the formula

$$L_{,} = 3.742\ E_{,}^{5.73}, \qquad (1)$$

where L represents hours life, and E watts per candle.

During the past year a great many tests have been made by Mr. Smith with the super-treated carbons of the Westinghouse stopper lamps, and the relation between life and efficiency thereby found to exist is illustrated by another curve, shown B, Plate I. With the same degree of accuracy as above, we may represent this curve between commercial limits by the equation

$$L_{,,} = 5.44\ E_{,,}^{5.684}. \qquad (2)$$

We note that this curve corresponds very closely in its general form to the curve of the treated burners, except that for a given efficiency the life of the super-treated burner is always longer. This is as it should be, inasmuch as the super-treated burner is, in fact, a treated burner which has been subjected to an additional process to render it more stable.

In 1888 Mr. John W. Howell presented a paper before this association, in which he exhibited a curve stated to have been constructed from the results of a large number of tests made with the Edison or untreated burners. I have taken the liberty of reproducing a part of this curve in this paper, shown C, Plate I., but using a different scale of measurement. It will be noted that this curve is very similar to the curve of the treated and super-treated burners; and, considered between the same commercial limits, we can express it with equal accuracy by the formula

$$L_{,,,} = 1.052\ E_{,,,}^{6.453}, \qquad (3)$$

$L_{,,,}$ and $E_{,,,}$ having the same significance as before. For a given efficiency we find the corresponding life of any class of carbon by tracing a perpendicular line until it intersects the proper curve, the corresponding life being found directly opposite the point of intersection horizontally. Thus, for an efficiency of 2.5 watts, we find the life of the untreated burner to be 400 hours, of the treated burner, 713 hours, and of the super-treated burner, 962 hours.

It is important to remember that these curves represent the results of laboratory tests, in which the electromotive force is kept more nearly constant than is ordinarily possible under the conditions of central station lighting. Therefore, in order to obtain an expression which will represent commercial conditions, we must introduce the element of a variable electromotive force. In Fig. 2 I illustrate a curve verified by numerous and exhaustive tests by Mr. Frank Stuart Smith, showing the relation between total energy consumed and the light emitted. This relation is such that a line drawn from any point of the curve to O (as AO) equals the tangent of the angle made by such line with the axis of X. It is represented by the equation,

$$I = \frac{W^2}{\sqrt{R^2 - W^2}} \qquad (4)$$

where I equals the total illuminating power expressed in candles and W equals watts, R being a constant, which depends for its value on the size and efficiency of the lamp. R is, in fact, the radius of the circle to which our tangent is referred. While the position of this curve varies with different lamps, the relation between the watts consumed and the light emitted remains unchanged through all tests. We know that the resistance of a heated filament will remain practically constant through the comparatively small variations in voltage to which a commercial lamp is subjected. Therefore, if we let p equal the per cent. variation in electromotive force, we may write from our fundamental electrical equation

$(1 + p)\,C = (1 + p)\frac{e}{r}$, whence

$$W_{,} = W\,(1 + p)^2$$

By a combination of this equation with formula (4), we get the expression (since $\frac{W}{I} = E$)

$$E_{,} = \frac{\sqrt{E^2 + 1 - (1 + p)^4}}{(1 + p)^2}$$

where p equals per cent. variation in electromotive force due to commercial conditions. Substituting this value of E, therefore, in equation (1), we get the expression for the commercial curve of the treated filament

$$L_{,} = 3.742\,\frac{[E_{,}^2 + 1 - (1 + p)^4]^{2.865}}{(1 + p)^{11.46}}$$

By substituting the same value in equation (2), we get the expression for the commercial curve of the super-treated filament

$$L_{,,} = 5.44\,\frac{[E_{,,}^2 + 1 - (1 + p)^4]^{2.842}}{(1 + p)^{11.368}}$$

Again, by substituting in equation (3) we get the expression for the commercial curve of the untreated filament

$$L_{,,,} = 1\,052\,\frac{[E_{,,,}^2 + 1 - (1 + p)^4]^{2.226}}{(1 + p)^{12.904}}$$

It is, of course, impossible within the limits of this paper to attempt to express all conditions; but by a comparison of laboratory and central station records a fair average assumption seems to be that, with proper attention to regulation, the commercial variation is equivalent to a constant excess voltage of 3 per cent. I have taken this as a basis, and constructed commercial curves for the treated, the super-treated and untreated filaments, which are shown as dotted lines in Fig. 1 and designated as A, B and C, respectively. It now becomes possible to calculate accurately the efficiency at which any class of lamps should be burned in order that they may yield the best economy.

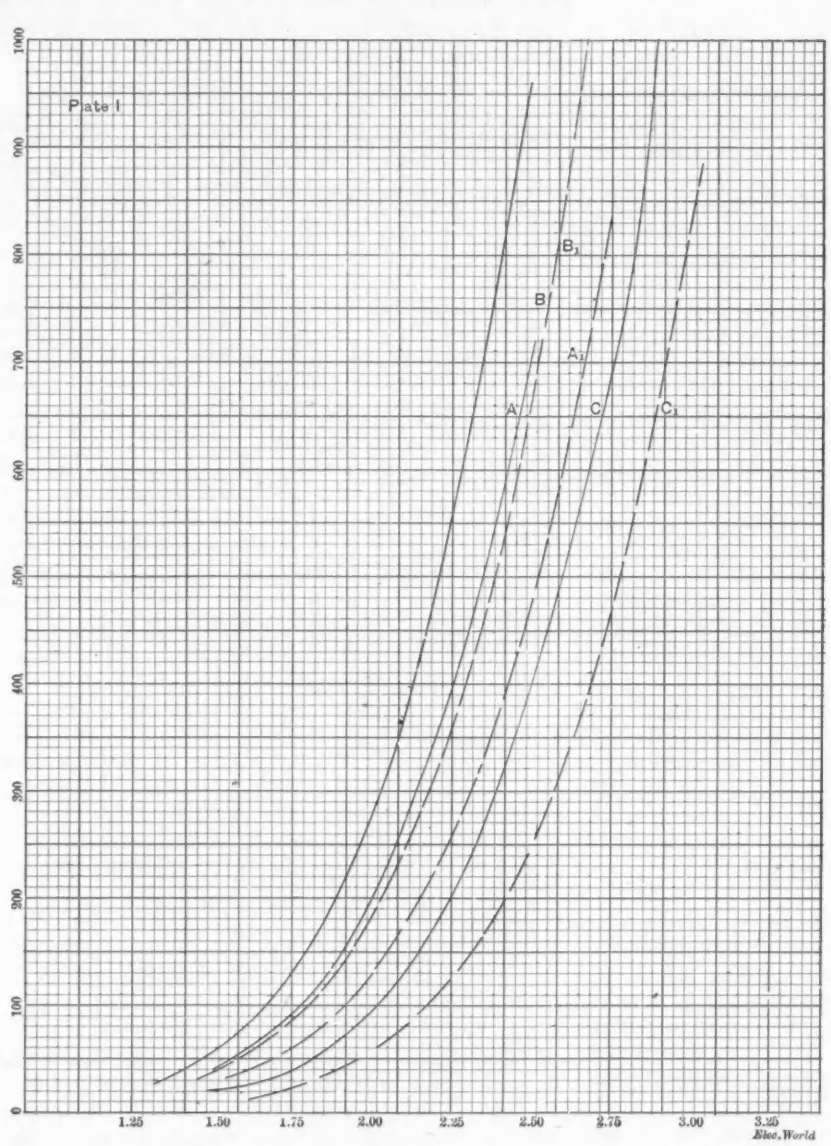
It is important to note the great effect that a comparatively small rise in electromotive force has on the life of a lamp. Any neglect to maintain the best possible regulation, therefore, will result in an increased bill for lamp renewals entirely out of proportion to the variation in voltage itself.

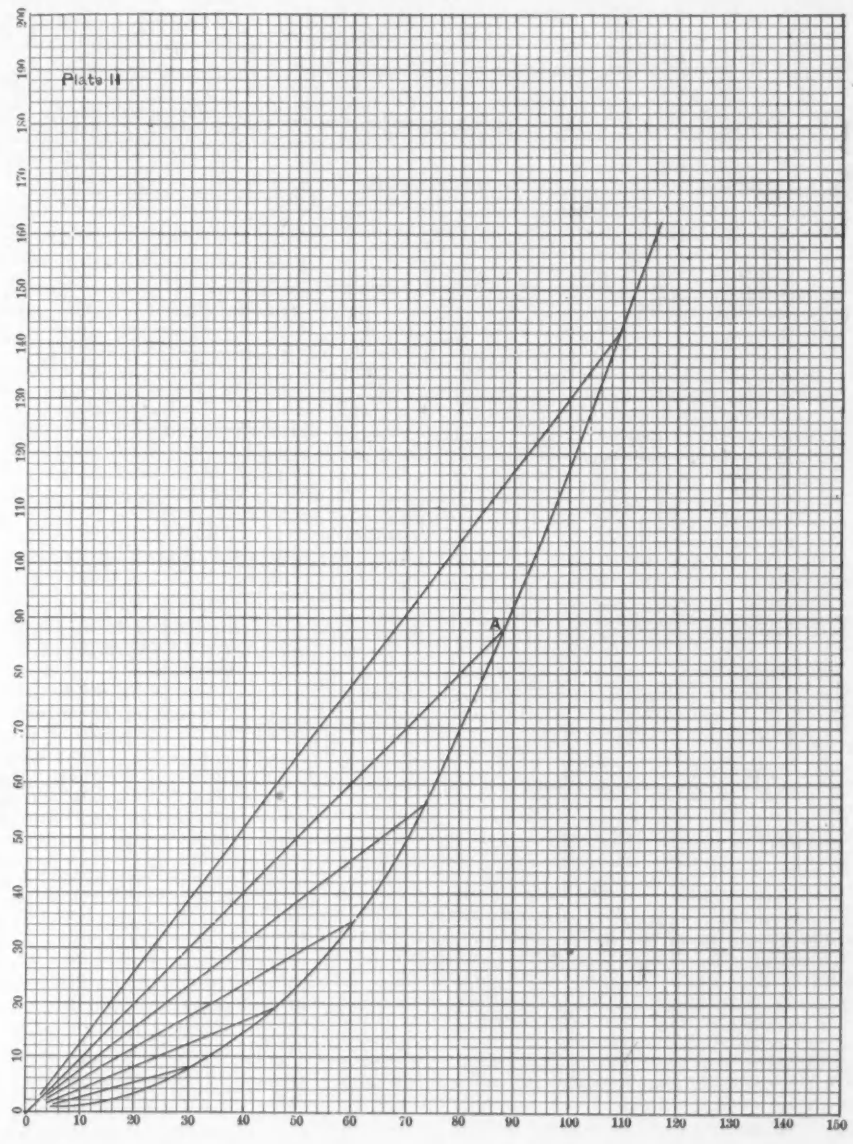
The condition of the incandescent lighting business throughout the country is undeniably prosperous. Everywhere central station companies are wiring additional lights or preparing to increase the capacity of their machinery. We will not be far wrong, therefore, if we assume, in the consideration of our subject, that the central station company has a market for all the lamp hours it can furnish during a certain portion of the day's run. With this assumption, let us formulate an expression for the profit in incandescent lighting, then we may determine what conditions will give this profit a maximum value. In the consideration of this matter I have taken as the unit of value one 16 candle lamp hour, assuming that what the public want is light, and that, other things being equal, they do not care whether much or little energy be expended to produce it. Therefore, whenever we can increase the efficiency of our lamp, we not only reduce the cost of the energy required to burn it, but also increase the lamp capacity of our station, lines, converters, etc., by a proportional amount. Owing to the fact that the various meters in use measure, not light, but energy in one form or another, when we make our unit the lamp hour and afterward increase the efficiency of our lamp, we must also increase our charge per unit of energy in order to maintain the same standard of price. Were any unit of energy to be taken as the unit of value, the receipts from a given output would become fixed, and the best lamp at once the most inefficient and longest lived. Political economy is clear, however, that to reduce the price of any commodity increases the demand for it, and in competition with other illuminants the only proper standard can be that of illuminating power. It is nearly always possible to change existing rates whenever it is proper to do so.

With our unit of value illuminating power, therefore, our profit will obviously be the difference between the cost and selling price of a lamp hour multiplied by the number of lamp hours sold. We may, therefore, write the expression—

$$P = (v - c)\,\frac{S}{W}$$

where P equals profit, V selling price, c cost of lamp hour, S output of station in watt hours for the time for which





FIGS. 1 AND 2.—INCANDESCENT LAMP CURVES.

our profit is estimated, and W watts required per lamp. Again, the cost of producing one lamp hour is clearly the proportionate cost of the lamp itself plus the cost of the energy consumed by it. We may, therefore, write—

$$c = \frac{l}{L} + \frac{g}{1000} W$$

where l equals cost of a lamp in cents, L its life in hours, and g cost of producing one kilowatt hour of energy. Substituting in this expression, from the formula of our commercial curves, the value of lamp life in terms of efficiency (bearing in mind that for a 16 candle power lamp $E = \frac{W}{16}$) and putting our expression for the value of c in place of c in the formula representing our profit, we have the equation—

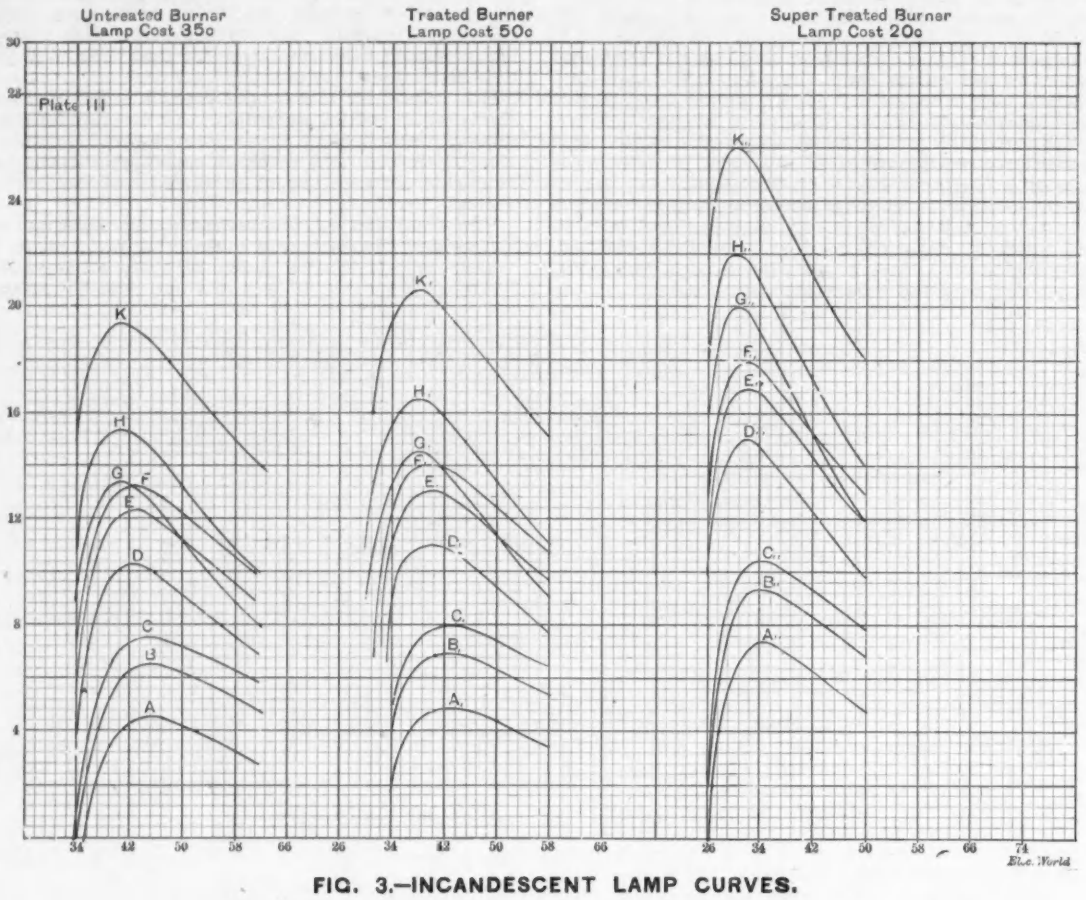


FIG. 3.—INCANDESCENT LAMP CURVES.

$$P = \frac{VS}{W} - \frac{Sl\,(1+p)^{2b}}{Wa\left[\frac{W^2 + 256 - 256\,(1+p)^4}{256}\right]^{\frac{b}{2}}} - \frac{Sg}{1000}$$

where a and b stand, respectively, for the coefficients and exponents of the second terms formulas (1), (2) and (3).

	A	B	C	D	E	F	G	H	K
V	.005			.0075			.01		
g	5	3	2	5	3	2	8	6	2

Curves similarly lettered are constructed with similar values of g and v, the differences in their position and form being caused partially by the different costs of the lamps and partially by the differing relations between the lives and efficiencies of the several classes of carbons.

I illustrate in Fig. 3 a number of curves constructed for the untreated, the treated and the super-treated filaments, using this formula. I have taken the original cost of the lamps at, respectively, 35, 50 and 20 cents, the selling price of a lamp hour at, respectively, .5, .75 and 1 cent, and the cost of producing current at, respectively, 2, 3, 5 and 8 cents per kilowatt hour. By the courtesy of a considerable number of central station managers, who have furnished data concerning their respective plants, the average cost of this energy appears to vary between 3 and 7 cents. The only cases where 7 cents is exceeded are those in which fuel is a very expensive commodity and the station output is small. Where 3 cents is too high a very cheap fuel is used and a very large station operated. In assuming these values, I believe that we have covered as nearly as possible the conditions which actually exist, but it is quite easy to adapt our expression to any set of local conditions.

In Fig. 3 you will note that the (Y) axis represents cents and the (X) axis watts per lamp, the station output estimated upon being the unit of one kilowatt hour. The highest points of our several curves represent the conditions under which our profits are a maximum, and the vertical distances between these highest points and any other points on the same curves show the loss in profit due to the use of a lamp of other efficiency than the most economical. The vertical distances between the highest point of any curve of one class of lamp and the highest point of a corresponding curve of another class of lamp show the profit or loss resulting from the use of different classes of lamps at their respective best efficiencies. Other combinations will be readily noted by observation. For example, with the price of a lamp hour at one cent and the cost of generating current six cents per kilowatt hour, the best result we may expect from the treated filament lamp at 50 cents each is with a 38 watt lamp, i. e., 2.37 watts per candle, when our profit should be (see curve H) 16.6 cents per kilowatt hour. With the super-treated lamp at 20 cents, other conditions remaining the same, the best results are obtained with a 30 watt lamp and our profit should be (see curve H) 22 cents per kilowatt hour.

Considering all these curves together, two facts are especially prominent, namely—first, that although we have assumed strictly commercial conditions, the profits obtained are in excess of those actually made in practice, and, second, that the most economical lamp efficiencies are considerably higher than those of any commercial lamps now in use. It is interesting and very remarkable to note that in every case the profits fall off very rapidly for lamps of either too low or too high efficiency, the variation being more marked where current is dear and running expenses high. By putting these facts together, it is apparently clear that the long lived inefficient lamp is a very expensive article, and that too much weight has been given to the cost of lamp renewals, which shows prominently on the expense side of our ledger, while we have not paid enough attention to the great waste of energy due to low lamp efficiency. By a reference to Fig. 1 we note that the most economical conditions call for, in the case of the untreated filaments, a life of between 250 and 525 hours; in the case of the treated filaments, a life of between 286 and 620 hours, and in the case of the super-treated filaments, a life of between 138 and 260 hours; the shorter life being in each case where both the cost and selling price of the lamp hour is high. I submit these figures for your consideration.

You will note from Fig. 3 that with a charge of three-quarters of a cent per lamp hour and five cents for the expense of generating one kilowatt hour, the use of a 50 watt lamp loses the operating company 1.05 cents for every kilowatt hour sold when using the 35 cent lamp with the untreated burner; 1.4 cents when using the 50 cent lamp with the treated burner, and 5.2 cents when using the 20 cent lamp with the super-treated burner, as compared with the profits which might be made if these various lamps were used at their respective best efficiencies.

It is gratifying to find that the possibility of increased profits carries with it the implied possibility of reduced prices to the public, and, therefore, a great demand for light, and greater success to the companies furnishing same, in competition with other illuminants.

I have said nothing in this paper in regard to fall in candle power, for the reason that, in both the treated and super-treated filaments, this fall is roughly proportional to the time the lamp has been burning, as compared to its total life; that is to say, if a filament has a life of 1,000 hours at a given efficiency, and during that time its fall in candle power is A per cent., if this filament is burned at an efficiency which will make its life 500 hours, its fall in candle power will still be approximately A per cent., so that our commercial results are not appreciably affected. For the untreated filament the fall in candle power is proportionately larger than in the other two filaments. Therefore, if we are making a comparison of total illuminating power per energy consumed, we must put the untreated filament on a somewhat lower scale than shown in the comparisons I have drawn.

DISCUSSION.

Mr. Burleigh, of Camden: To those of our members who were able to follow the formula of Mr. Townley's paper it must have been interesting. To me a great deal of it was lost. Of course I am not able to follow out the mathematical part of it. My only excuse in rising to speak to so formidable a paper is that I am in great difficulty just now. It is not as to which kind of carbon lamps, treated, untreated, or supertreated, but as to how I am to get any at all. To my last order the reply was: Your valued order received; owing to the shutting down of our factory, we will not be able to fill it. If Mr. Townley or any other gentleman could tell me whether I should be justified in entering into a long time contract for lamps, or whether I am to hope to get a lamp, to obtain which I shall not have to enter into such a contract, I should be obliged. Mr. Townley refers in his paper to a certain lamp. I would like to ask him if we may expect such a lamp soon, and if it will be generally supplied to those wanting to use it, or if there will be such contracts as are imposed by the other people who manufacture lamps?

Mr. Townley: I suppose the gentleman refers to the stopper lamp. If so, I can say that they are being made and supplied every day.

Mr. T. C. Smith: I have been identified with the association for a long while, and I think there are members here who know that I have been one of those who has always declared for the central station man as against every other element in the association. I was one of the first to urge that supply houses should only be made associate members; but I was also one of those who always strenuously urged that their representatives should have the right of the floor in the discussion, and every other privilege except voting on the official action of the association. I did this because at the time there were a good many papers such as Mr. Townley's, of the utmost value to the central station man. It has been urged against such papers that they are to a very large extent means of advertising. We are willing to let them go at that. They create discussion on subjects of great importance to us all. If, as it would appear at present, there are only two companies that are going to supply lamps to central station men, we are in very poor shape. I have no axe to grind in this matter, our station being in the fortunate position of having been in business prior to July 14, 1891. The General Electric Company must supply us lamps. They have been very nice about it, with this unfortunate distinction—that because we are in a town in which there is a local Edison company, we are compelled to buy Edison lamps. I do not want to tread on anybody's toes. I am only giving my own experience, and that is, that the Edison lamp for a central station man is the poorest lamp on the market to-day. (Applause.) We have gone to the General Electric Company, and said: Gentlemen, we do not use many lamps; we are in the fortunate position of not supplying many renewals to our customers; we have discouraged that, and want to get in the position of the gas companies and supply current through meter. We do, however, supply renewals to a few customers, and we do not care particularly about the price of the lamp. You tell us the Edison lamp is 35 cents. If you will furnish us Thomson-Houston lamps at 45 cents we would rather buy them; or if you will furnish us Sawyer-Man, Perkins or Beacon lamps at 50 cents we would rather have them. They answer: "You cannot have these. The Edison company has the right to sell lamps in this town, and you have got to take that lamp." That is the condition of affairs, but it does not affect us very much; but more than half the central stations have to supply their customers with lamps. They are compelled to take the lamp they do not want. The price has not been raised to any excessive point, however.

I think this association ought certainly to take some steps, either as a body, or bring its members to some concert of action, to break up this state of affairs. The result of competition in any line of trade is improving. I do not think I can take any better example than the transformer. Leaving out of account the rights of the case—who was the inventor, or who had the best claim—I think no one will deny that the converters at present are not only cheaper, but are 50 per cent. better than the converters we used four or five years ago. This has come from the fact that one company would make an improvement, and another company would try to beat them.

The method of dealing with the question before us is a difficult one to outline. I would say, however, that if any discussion takes place, I hope it will be moderate in tone. There is absolutely nothing to be gained by abusing the fellows on top. They are there. The law has given them the right, no matter what are the equities of the case. What the judges thought of the equities of the case their decision shows; but, unfortunately, the parties in question have the legal right to do this thing. The statement has been made that the company having absolute control will not raise prices, and will not make any arbitrary distinctions. They do make these distinctions, in the fact that they compel you to take a particular form of lamp. The idea that any individual or corporation with absolute power in its hands will not use that power is too ridiculous to give consideration for a moment. You will remember that the statement was made in court by the counsel that there was no intention to shut these factories up; that they only wanted their rights to get royalties. But I made the inquiry of an authorized official of the General Electric Company whether other lamp manufacturers would be licensed. He told me in so many words: "We propose to have this business, and we are going to get it, and you fellows will have to pay the price." Immediately after that came up the question of the Goebel lamp. The change in policy was apparent at once, and will remain so until the final decision is reached. The minute they get hold of that they will be there again as strong as ever. I do not want to go into the equities of the case or go over the history of it. I want to get right down to the meat of the question, which is: "How are the central station men going to right this?" I do not think there is a central station man who wants to swindle the General Electric Company or the Edison company out of anything that the law gives them. They have spent a great deal of money to get this monopoly, and there is no reason why they

should not be sustained in it; but I do not think that they should tie us down to using something we do not want. It seems to me that the whole equity of the case would be met if the General Electric Company did as they very plainly hinted they meant to do, and as they wished the impression to go abroad, and that is, that they would license the various lamp manufacturing companies and charge a royalty. If they do this, I will have no objection. The Edison lamp is made at 40 cents, we will say, the Thomson-Houston at 50 cents. I am perfectly willing to pay 10 cents a lamp more for a lamp of any of about ten different makes. It seems to me if we could bring that state of things about we would all be satisfied. Let them decide what is a fair royalty to charge. Let them give us a chance to get what we want. Give the lamp manufacturers a chance; the moment the price is at a level, that moment they will have to get the trade by improving their product, instead of lowering the price. We want the best lamp, and the best lamp will of course in the end be the cheapest.

I do not know that I can say very much as to the policy to be pursued on this question. I know what mine shall be—that I will never buy one cent's worth of material from the General Electric Company until they do that thing. (Applause.) I shall never buy one cent's worth of supplies from that company that I can possibly buy from an independent concern; and I shall do all in my power to advance the sale of any lamp which is put on the market which can be manufactured without coming under the law of infringement.

President Ayer: This topic is very interesting and properly should be discussed, but the hour is getting late, and we have considerable business to transact. I do not wish to convey the idea that I want to limit or restrict discussion. I desire, however, that gentlemen will speak briefly and to the point.

In relation to this matter I will state that we have a standing Committee on Relation of Manufacturing to Central Station Companies. That committee and our Executive Committee, I can assure the convention, will take such steps as are necessary to bring about the results desired by the association. These gentlemen will look after the matter, and this thing will naturally be followed up. These committees are composed of central station men only, and they are the men best calculated to carry out the objects of their appointment.

Mr. Howells, of Newark: I was not surprised at all to hear the applause that greeted the statement concerning the Edison lamp. I do not wonder at all at some of the experiences with the Edison lamp, especially at stations where the regulation is anywhere from three to eighteen volts more than the normal pressure at which the lamp should be operated. I have made a specialty for the last few years of meeting complaints against the life and performances of Edison lamps. I could bring here a vast amount of data to show the reasons why people had had poor results with lamps, why lamps had performed badly on their circuits; but to get right down to the pith of the matter, a lamp should be operated at the voltage and candle power marked on the lamp. A 16-c. p. lamp should be operated at 16 c. p.; not 24. A lamp intended for 110 or 114 volts should be operated there. A lamp of 3.1 watts should be operated more closely than a lamp of 4.2 watts, for obvious reasons. It is a well established law, and one I have found to be familiar to many, that there is a great decrease of life with increase of voltage; and that law is this: Three per cent. increase of pressure halves the life of lamps. That is good for all lamps. Three per cent. on a 50-volt lamp means 1½ volts excess. That 1½ volts excess will halve the life of the lamp. If it be a 3.1-watt lamp, and the average life of the lamp under proper conditions be 1,000 hours, that 3-volt excess will halve the life, or bring it down to 500 hours average life. If you are using a 3.6-watt lamp, whose average life may be about 1,800 or 2,000 hours at normal candle power, that 3 volts excess pressure will reduce the lamp 1,000 hours. In the case of a 4-watt lamp, the average life of an Edison lamp will be about 3,000 or more hours, at normal candle power. You may abuse that lamp very much. Your 3 volts excess pressure will halve the life. Increasing the pressure another 3 volts, or another 3 per cent., will bring it down again to half of that, or one-quarter the life—750 hours. That is the reason why the Beacon, Sunbeam, Perkins and some other lamps are better than the Edison lamp.

They are a 4-watt or 3.6-watt lamp, and they will stand all kinds of abuse and give you a very fair commercial life. In buying lamps you should buy lamps to suit your conditions of pressure. If you can maintain on your circuits a constant pressure with a variation of only 1½ or 2 per cent. above or below normal, which is very good, you can operate a 3.1-watt lamp with very excellent life—about 800 hours. If you cannot maintain your regulation or do not care to maintain your regulation, you will buy a lamp of lower economy—3.6 watts. If you have commercial reasons, or reasons based on competition, and wish to run your lamps high—if you wish to buy a lamp of 16 c. p. and run it at 24—if your reasons are good for doing so, and you are satisfied with the ledger balance, buy a 4-watt lamp and run it there; but remember that the life of the lamp is always halved by 3 volts excess of pressure, and another 3 volts will bring it to one-quarter of what it would be if operated at the candle power for which it was intended. I have for the past year or eighteen months investigated a very limited number of complaints from Edison central station men, and in not one case have I found a fault to exist with the Edison lamps. In every case I have found the pressure too high. In every case when short life of lamps was proved, the pressure has made the life of the lamp short. In no case have I found a shipment of poor lamps from our factory in eighteen months. The Edison lamp is not a poor lamp; but it is not as tough at 3.1 watts as it is at 3.6 or 4 watts. You pay your money and you take your choice.

Dr. Louis Bell: I am very loath to enter into this discussion, and it is with great hesitation that I take any hand in it whatever. Although I happen to be with a particular company, about which some remarks have been made, I first of all want to be of service to the National Electric Light Association. I do not believe this association should be made a cat's paw to pull commercial chestnuts out of the fire by anybody. It is not the purpose for which it was founded, and I consider it not only bad form but discourtesy to the association to bring commercial matters into dispute before it, unless at its specific request. I believe it is the intention of the company in question to do, in so far as it is in the power of any corporation, justice to all parties concerned, and to protect central station men who have entered into contracts with either component part of it. There are a number of manufacturers interested in this question, and each thinks the other has transcended his rights; and the question is naturally a hard one to settle, and somebody's feelings are going to be hurt. The only thing to be done to it is to go over the matter carefully and endeavor to do justice as nearly as possible to all parties concerned. I think there are many men in this association who appreciate the exact condition of things; and to them I think the matter had better be left.

Mr. Bell also animadverted upon the taste of a person taking the stand which Mr. Smith had who himself had so recently written an article laudatory of a certain make of machinery, and then lacked the courage to sign it with his own name, but, instead, had substituted three stars. Those who had had experience in journalism knew that a signature of this kind was that of one who had not the courage to come out over his own name, with the remarks to which he wished to call public attention.

Mr. Smith at once jumped to his feet and demanded to know what communication was referred to. He stated that he had never written an article for pay, or one that he considered of importance, that he had not been willing to sign with his own name and that he was totally in the dark as to what Dr. Bell referred to in his recent remarks. At this juncture Dr. Bell again rose, and replied that if Mr. Smith disclaimed the authorship of the article in question he would withdraw his remarks as applied to him, and at once offer an apology for any strictures of a seemingly uncomplimentary personal nature which he had made in regard to Mr. Smith; that he intended no reflection on Mr. Smith's honor, and that he hoped with this that the matter would be overlooked. Mr. Smith then arose to a question of order and demanded again to know the nature of the communication to which Dr. Bell referred. The latter then passed over to Mr. Smith a marked copy of the St. Louis "Republic," of March 2, in which on page 12 appeared an article on the electrical development of St. Louis, in which Mr. T. Carpenter Smith, in a reputed interview, is quoted as having stated, in substance, that the Missouri Electric Light and Power Station was an ideal one, and had arrived at a state so near perfection that it could not be duplicated with any other machinery than that of the Westinghouse make. This article was signed with three stars. This ended the discussion on this particular point, but in regard to the object of the association, Mr. Smith said:

I think Dr. Bell has misunderstood the object of this association when he says it was not organized for commercial purposes among the members of the central stations. Such an utter and absolute going back on all that we have done at the different conventions, at each of which I have been present, I have never heard before.

President Ayer: I think this matter can be left in the hands of the committee appointed for the purpose of considering such a question, and who will take into consideration the grievances, the wants, or desires of the central station interest. I shall be pleased to have some member move that the discussion be closed and the matter referred to that committee.

Mr. De Camp: This is a subject of very great importance to central station men. There is one thing, however, that I think can be relied upon—that we central station men wish the manufacturers to understand, whether it be one company or another, that we are more disposed to criticise the quality of an article than the price; and that if they will make an article worth the money the central station men are perfectly willing to pay for it. (Applause.)

I do not know of any better way of getting into communication with the manufacturing companies on this subject than to refer this question to our committee; and I therefore move that the matter be referred to the Committee on Relation of Manufacturing to Central Station Companies.

The motion was put and carried.

Morals of Corporations.

BY E. A. ARMSTRONG.

When I first named the title I proposed to use for my paper, naturally I was the recipient of all sorts of suggestions. One friend was sure that it would be as short as the famous chapter on snakes in the history of Ireland—there are no snakes in Ireland.

A clergyman was more vehement. He was the one who took that limited meaning of morals, meaning morality, and he undertook to tell me that from the first they were combinations of and for evil, or, at least, easily swayed by evil influences. "Why," said he, "the first corporation of which mention is ever made, and it is in the Bible, brought death and misery into the world, and that same history has ever repeated itself." Upon seeming to be a little sceptical, this was reiterated, and then, when I rose to his bait, and begged to know what this corporation first mentioned in the Bible was, he gleefully shouted: "Eve, she was 'Adam's express company.'" He being a preacher, of course it was not admissible for me to kill him right there, so I had to content myself with assuring him that the modern "Adams Express Company" was, in law, as I was credibly informed, a partnership, and each shareholder a partner, and that it was not a corporation at all, and that, while his comparison was very perfect, it did not fit, as his ancient one was likewise a partnership, Eve surely being a joint partner. I was not sure enough my accuracy in Biblical knowledge, or I suppose I might have retorted about the Company of Angels! Isn't it wonderful how many bright things you might have said that you think of the next day! I once heard the query made, What becomes of the bright and good things you meant to say and didn't? With equal force we may inquire, What becomes of the bright things thought too late?

I don't mean, however, if I can help it, that the charge brought against the colored preacher's text and sermon shall be true here. In that case it was said had they ever chanced to meet they wouldn't have recognized each other. This subject is not so peculiar as some might have thought it, I take it. Let us see how near right I may be.

A corporation is best defined by saying it is an artificial person, possessing certain limited rights, powers and privileges, with a life varying in each case from a few years to perpetual existence. Nothing very formidable in that, it would seem. I did think that at first I would give some of the more elaborate legal definitions which we have of them; but it occurs to me that possibly this that I have given is as good as I can do; and, indeed, it fully describes them.

That there is a popular distrust, if not actual hatred, of corporations, as such, is undoubtedly true. I suppose a myriad of causes may be found and properly credited as the source of this. It is fed by as many springs as is this mighty Father of Waters, perennially washing the levees of this city. The effect of the volume gathered is often as cruel, relentless and as disastrous as the river when abnormally charged. I have thought more or less upon this subject, and if called on to give my reason for the first origin of this hatred or distrust, I would remind you how they were first created; would ask you to remember the time when the King's Letters Patent, his seal and writing, made the charter—what special powers, privileges, liberties and immunities were given, and for what purpose and upon what consideration—many of them, like ancient titles of nobility, not being able to bear investigation, and then ask you if you needed further search.

A corporation of to-day, however, is vastly different from any of these, or, indeed, of those not half a century old. In most of the States I apprehend their creation is very similar to that of my own State, New Jersey. With us, corporations are formed under general laws passed for particular classes—insurance companies, religious societies, beneficial organizations, hospitals, lyceums, libraries and miscellaneous business corporations, all having their respective acts. A corporation under any of these acts may be formed for the desired purpose by making and filing articles of association setting forth the prescribed requisites. When this is done, by operation of the law a corporation is formed. For many purposes only three persons are required. There is no charter, no grant, no executive, legislative or judicial act, required. To be sure, I speak of the present. Before 1875 is was possibe to obtain a special legislative act of incorporation. Now, a corporation being created in this way, is it just or reasonable that it be condemned per se? I cannot think that it is, because the inherited antipathy is both unjust and unreasonable. It is not, nor can it properly be, a class condemnation, even should individual cases merit it.

If in this age and in this presence I should say that this country owes more to corporations than anything else, I don't know how I should be regarded. In some places I know that if I desired to retain as much popularity as any man ought to court, that is, enough to live peaceably beside his neighbor, I would not dare say it. But would it not be true? These same people who, in one breath, condemn corporations, in the other deify co-operation—crucify the doer and crown the deed. Co-operation has been, and in all probability will be, in all ages the panacea offered for most of the social ills of the time. We are wont to depreciate, and rightfully, too, I think, disjointed individual effort. Guerilla warfare, while exasperating and annoying to the enemy, accomplishes very little. Less than a hundred organized, drilled and experienced men may readily put a thousand in a mob to flight. The same will hold good in economic and business relations.

If there is to be any great work carried on—charitable, religious or educational—what is the first agency we employ? Association, to be sure, by means of incorporation. We would not think of undertaking it without this agency. It puts the little, insignificant and separately powerless portions into one mighty effective whole; and by it, through concentrated, earnest effort, undreamed of results may be obtained. We find it everywhere. Beneficial organizations, life insurance associations, trades unions, all join with one purpose, to get the wisdom, strength and power of aggregation. We are not prone to condemn this, nor should we be. It is a good and glorious thing.

If, then, so far I am right, the conclusion follows that

a corporation is a desirable and a necessary thing to accomplish the greatest good with the least expenditure of energy and wealth. If what I have said does not prove that to your satisfaction, I shall want you, for the sake of my argument, to assume with me it to be proved, for I propose to so consider it. Now, then, comes my application, and I propose to consider it in two aspects. The first are the moral obligations from a corporation to the public first, and then to the individuals composing the public. The second are the moral obligations to a corporation from the public first, and then from individuals; as they can best be considered together, I shall not formally group or place these two headings, but run them right together. Nor do I propose to deal with corporations generally; but, as this is the National Electric Light Association, I propose to consider electric light companies particularly.

The quasi-public character of much of the business of almost every electric light company in its dealings with municipal authority must be emphasized. Every company doing such service occupies such a position of trust as to require it to give a maximum of service at a minimum of cost. Don't misunderstand me. It is not only the privilege of an electric light company to receive, it is its duty to demand, fair compensation for what it provides and furnishes. It is just as dishonest for it to take advantage of its position and crowd the municipality as it is for the municipality to reverse the tables. We have often taken occasion to complain of the unfair treatment given companies by municipalities, but too often the treatment has been invited. When a corporation such as ours makes a large investment for public lighting, and while it continues to regard what I have indicated as its duty regarding service and charges, it has the right to expect a continuance of the municipal—patronage, I was about to say—service, I will substitute. Any deviation from this, while not a violation of an express, is the violation of an implied contract—something in law just as binding when defined, and therefore surely ought to be in morals.

I imagine I might amplify this to a considerable extent, but I will not, further than to say what applies to corporations acting with each other and with individuals, as may hereafter be stated, will all apply, and really with more binding force, upon the relation with the municipal or governing corporation. Such a corporation being a part of the governing machinery, it is bound in law, as well as in justice, to treat with absolute fairness every person alike. It is dishonest for it to take anything for public use from its citizens at less than cost. When that is accomplished, that most undesirable of all things, municipal ownership of electric light plants, will be undreamed of and unconsidered. No matter how utopian may seem the idea of the government doing everything possible, it is the idea most foreign to our notion of government—especially the American idea. Everything possible is to be left to the people, with as little government as possible. A despot could administer the government of this country much more effectively and economically than we do by our cumbersome representative system, pervading every department as it does, assuming his honesty, goodwill and ability; but it would prove far from satisfactory, to be sure. We prefer to govern ourselves, although we may not do it so well and it does cost us much more.

Such, briefly, is the way in which our corporations and our governments should regard each other, as I take it. Be mutually regardful of the duties and responsibilities of each other and properly regarding their reciprocal obligations. Each one can further carry out the argument to his satisfaction.

That there is, to a wonderful extent, this appreciation of obligation on the part of the companies is a thing very pleasant to contemplate. If accident or disaster happens to a company, just see what heroic effort is put forth to remedy it. Men and money are never spared. The inquiry is made, Can it be done? And if it be answered affirmatively, immediately comes the decree: Then do it. A notable instance of this, the latest of many coming under my observation, be it said, is that of the Buffalo plant. Our friend and former President Huntley worked with more than his accustomed vim and vigor to make his plant a phoenix, and did it because his first desire was to serve his city.

Say what you will, gentlemen, this is patriotism. Not such as marble shaft or brazen tablet commemorates, but it is a part of that great, grand total which makes a country great. The strength of a country's army may be well measured or best measured by its reserve force. These things give us confidence. Sporadic and meteoric heroes may, under the stress of great circumstances, spring everywhere and from anywhere. It requires sterner stuff to go in where no glory comes, and often disaster or death. The unknown and uncrowned heroes ought to be remembered.

How, then, should corporations regard each other and regard individuals? As I take it, the obligation of the Golden Rule: "Whatsoever ye would that men should do to you, do ye even so to them," is none the less binding upon man in the aggregate. "A man's a man for a' that." He is simply occupying another relation. Now, no matter to what length I carry this paper, I cannot say more than I have said in the statement of this. It may be I may make it slightly plainer, but the foregoing is the truth, the whole truth and nothing but the truth.

It is the duty of our corporation to use the best methods it knows or can learn, adopt all the improvements, and render the best possible service, and that at as reasonable a figure as it can afford to do it, having a just appreciation of the risk the capital invested sustains, which is entitled to an adequate return. If you can furnish light or power at a less figure than you are now receiving, and still pay your stockholders a fair return, it is your bounden duty to voluntarily reduce your prices, so that those who make your business possible may have their share in your prosperity.

Don't try and find the maximum your customer will stand, but find how little you can afford to charge him, and deal with him on that basis. He will soon find it out, and it will pay you better than the other course, if that should be your highest aim. It doesn't pay to make too much money. Understand me, I speak from observation, not experience, for I haven't sinned in that line. I am much like the youngster beside a brook one Sunday afternoon, intently regarding an immovable float on the stream, fastened to a fishing line held in his hand, to whom a good man said in those deep, tomb-like tones which some men use to speak of religious matters: "My boy, don't you know it is wicked to catch fish on the Sabbath?" and who replied, without taking his eyes from the float: "Guess I ain't sinned much yit, then. Ain't had airy bite."

Honesty is the best policy, indeed; and by it I mean honesty in its fullest and broadest sense. It has only been a comparatively short time since it was your bounden duty to inquire for the lowest price when you went into a store, and after you made your purchase you were not sure but that if you had held on you could have secured a lower price. You were much like a friend of mine, who said, in buying a piano: "Why, you get it at your own price, and then you feel that you are stuck." You may be able to push and crowd your customer and get big prices for a while, but his turn will come after a season, and then there will be no need for you to ask the rocks to fall on you and hide you, for he will attend to all that. At that time what shall avail you all your former high prices? My plea in this is, regard the Golden Rule. It pays in the long run.

So far as I have been able to learn from observation, central station companies of themselves have been very considerate and mindful of each other. The poaching has been at a minimum. To be sure, I exclude from this entirely the assisted and inspired organizations that masquerade under the name of local companies. This amicable and creditable feeling is, as I take it, largely due to this association and to our electrical papers. The more people know and learn the more tolerant and less bigoted are they. The world is not nearly so bloodthirsty as it was a century or even a generation ago. In all things it seems as if we were more nearly approaching the millennium. Business is not excepted. Our congresses, our conventions, our papers, everything that has wisdom, if not everything that has voice, leads and teaches in this direction. Let us be duly thankful. The time may come when Frank Stockton's War Syndicate may in like manner be a national realization.

There is one branch of this subject I have not named, and that is the attitude of the parent and supply companies toward the companies of our association. They, of all people, ought to have regard for us. Indeed, they have in times past had the greatest regard for us, in fact, quite an absorbing regard. Too often, indeed, it has been the fabled regard that the wolf had for little Red Riding Hood.

You know one of our standing committees is upon the relation of parent and sub-companies, and one of our members, upon seeing the announcement upon the programme, at one time, said: "Well,' judging from my experience with them, the relation is that of a stepmother." His experience, alas, was not an uncommon one. Let us hope the era of peace and goodwill has had its dawn.

I do not think that I ought to prolong this further. It may be I have said nothing new, or brought no new thoughts to your mind. But I have said what I had to say. Certainly the preaching of the Golden Rule is nothing new. Its application ought not to be. I only want to emphasize the fact that because men are associated into a corporation, and, therefore, lose some financial responsibility, they do not thereby lose also all moral responsibility. It would sometimes seem as if the old saying, "a corporation has no body to be kicked or soul to be damned," was also true of the corporators. They are like the old lady who in a religious discussion said, when asked what she thought of the doctrine of total depravity, that it was a good enough doctrine, if lived up to. They, it would seem, are willing to live up to their given character.

As corporations can do what as individuals would be impossible, the aggregation of the littles will accomplish wonders, just as brick after brick makes the tallest and grandest structure. But the beauty and the strength and, indeed, the utility of the world is absolutely dependent upon the perfection of the single one—the individual. Therefore, follow stockholders and officers of corporations, in all these things "Be ye perfect."

Convention Notes.

Mr. G. H. Keating, of Bay City, Mich., represented at the convention the H. M. Loud & Sons Lumber Company, of Au Sable, Mich. This company does a large and increasing business with electric light, electric railway, telephone and telegraph companies, supplying them with cedar poles, cross arms, etc. Mr. Keating had just returned from a trip South, where he had secured one or two very nice contracts.

The Big Four of the electrical special were: Messrs. R. B. Corey, of the Ward Arc Lamp; Geo. J. Jackson, of the Norwich Insulated Wire Company; C. D. Shain, the New York representative of the Siemens & Halske Company, and T. Carpenter Smith, of the Keystone Electric Company, of Philadelphia. Messrs. Jackson, Shain and Corey returned to New York on "The Pennsylvania Limited" from Chicago Saturday afternoon These gentlemen live principally on angel cake and similar delicate edibles

Mr. George J. Jackson, treasurer of the Norwich Insulated Wire Company, had his first experience of an electric light convention at St. Louis. He enjoyed the convention so much and made so many pleasant acquaintances that he has already asked Master of Transportation Baker to reserve a section for him on the electrical special for the next convention.

Mr. H. C. Adams, of New York, representing the Phillips Insulated Wire Company, of Pawtucket, R. I., made many friends during the St. Louis meeting. In referring probable customers to those at the convention who were already using the wire he represents, any inquiry on the subject invariably brought out the information that the wire Mr. Adams sells is "O K."

Mr. P. C. Ackerman, the New York representative of the American Electrical Works, of Providence, R. I., was on hand, as usual, but the wires manufactured by Eugene Phillips are so well known that most of Mr. Ackerman's time was devoted to discussing general topics and taking orders. He, however, sold the Union Depot Railroad Company while in St. Louis 30 miles—about 20,000 pounds—of 0000 weatherproof wire. Just before starting for the convention Mr. Ackerman sold an additional 30 miles of feeder wire—500,000 circular mils—to the Brooklyn (N. Y.) City Railroad, having sold to the same company 70 miles of the same wire last December.

Nikola Tesla never lectured before to as large an audience as he did in St. Louis, and probably never will again. The hall in which the lecture took place seats about 4,000, and not only was every seat filled when the lecture began but even standing room was at a premium.

Mr. George T. Manson, of the Okonite Company, was at the convention, and, as usual, had a number of interesting samples of Okonite wire with him. "George Manson" is always one of the most popular men at these meetings, except it be his chief, Captain Candee, of the same company, whose goodnatured face was missed at this convention. The Captain has recently returned from a business trip in Europe, and had found on his return so many matters demanding personal attention as to prevent his leaving New York at this time.

Mr. E. W. Little and Mr. Romaine Mace showed the Lundell motor and some other interior conduit specialties at the convention. Mr. Mace also distributed a handsome pamphlet showing some of the noted buildings recently wired with Interior Conduit Tubing.

Mr. H. G. Issertel, a member of that enterprising New York corporation known as Alexander, Barney & Chapin, is said to have as many acquaintances among those connected with electric lighting and the street railway industry as any man "on the road." Mr. Issertel made many friends at the convention by distributing handsome little boutonnéres to the gentlemen and corsage boquets to the ladies. Readers of THE ELECTRICAL WORLD who have had dealings with Messrs. Alexander, Barney & Chapin will be glad to know that the business of this incorporated company is increasing very rapidly. Mr. H. J. O'Riley, the secretary, gives his own personal attention in the home office in New York to the filling of orders, and this, perhaps, accounts for the fact that customers are so well satisfied with the manner in which their wants are attended to.

Mr. M. M. Hayden, of New York, attended the convention to meet in a social way those of the delegates who were users of the well known Law battery. Mr. Hayden has now full charge of the manufacture and sale of the Law battery, Mr. Childs, his predecessor in this position, now giving his attention to the Law switchboard.

Mr. Louis Cassier, proprietor of *Cassier's Magazine*, was at the convention, accompanied by Mrs. Cassier, and both seemed to enjoy the proceedings thoroughly.

The Fort Wayne Electric Company was well represented at the convention by Messrs. Jas. J. Wood, C. S. Knight, and C. S. Bradley. The new and excellent Wood arc lamp, manufactured by the Fort Wayne company, was exhibited in parlor 66, where it attracted much attention and called forth many compliments.

Mr. George Cutter, of Chicago, representing the Germania Electric Company, the Simplex Electric Company, and several other important Eastern manufacturing companies, had a handsome display in the corridor of the Southern Hotel. Mr. Cutter, unfortunately, had broken his spectacles the day before he left Chicago, and without them his eyes pained him so much that he was forced to leave the convention on Wednesday night and return to Chicago, much to the regret of those present, for few who attend the conventions are more popular than Mr. Cutter.

Messrs. J. W. Marsh, of Pittsburgh, and Fred E. Degenhardt, of Chicago, were on hand to talk up the wires and cables manufactured by the Standard Underground Cable Company, but they did not seem to find it necessary to say much in their favor, for the goods of the Standard Underground Cable Company are very well known in the West.

Messrs. F. S. Terry and D. E. Goe were on hand to represent the Ansonia Electric Company, and to explain the reasons for the recent change in name. As they do this in a full page advertisement in the present issue of THE ELECTRICAL WORLD it will not be necessary for us to say anything on that subject here,

Mr. Wells Goodhue, of Taylor, Goodhue & Ames, circulated among the crowd and exhibited an exceedingly neat wooden model of the Diamond Transformer, which is meeting with such a large sale, not only in the West, but also in the East.

Messrs. W. H. McKinlock, of the Central Electric Company, and W. C. McKinlock, of the Enterprise Electric Company, of Chicago, attended the Convention, accompanied by Mrs. W. H. McKinlock. Mr. McKinlock says that so many of those present are his customers that he finds it very pleasant to attend the conventions to shake hands with them.

Mr. S. F. B. Morse, the Western representative of Brixey's Kerite wires and cables, was quite active during the convention. It is no wonder that a man with so historic a name should make such a success of so excellent a wire.

Mr. G. L. Reiman, president, and Mr. J. A. Mosher, vice-president of the Mosher Electric Company, were present to assure the delegates that the new Mosher lamp is what alternating current managers have so long been looking for.

Mr. D. P. Perry, president of the Standard Electrical Company, of Chicago, moved about among the delegates, explaining why, in his judgment, the system of the Standard Electrical Company had been so successful, and laying special stress upon its simplicity and efficiency, and the little likelihood there is of its getting out of order.

Mr. J. Scribner, of the General Electric Company, of Chicago, did a most excellent piece of work in the way of looking after the transportation of Chicago delegates. No fewer than 90 delegates came from Chicago, 45 of them on the train under Mr. Scribner's management. This is the largest delegation from Chicago that has ever attended an electric light convention in any other city. Mr. Scribner seems to be to Chicago what Mr. C. O. Baker, Jr., is to New York, and both delegates deserve the highest praise for the thorough and satisfactory manner in which they looked after the matter of transportation in connection with the recent convention.

Dr. Wellington Adams, Prof. Nipher and Mr. George F. Steedman, of St. Louis, and Mr. E. F. Seixas, of Chicago, contributed considerable in the way of knowledge to the delegates regarding the Chicago & St. Louis Electric Railway, contracts for the grading of which have been recently given out. Very general interest was manifested on the subject, and many questions as to the methods to be employed were asked of Dr. Adams, Prof. Nipher, Secretary Steedman and Press Agent Seixas, which were all promptly answered. The delegates and the visitors present wished the ambitious undertaking the most unbounded success. On Thursday evening, Dr. Adams, Prof. Nipher and Mr. Steedman gave a most enjoyable dinner party to a number of prominent electricians present at the convention, including Edward Weston, of the Western Electrical Instrument Company, Dr. Louis Bell, of the General Electric Company and Messrs. Fred. A. Scheffler, of the Brush company; C. S. Bradley, of the Fort Wayne Company; also Prof. W. S. Chaplin, President Jas. I. Ayer and H. S. Pritchett, and Messrs. H. A. Wagner and Mr. Steedman, of St. Louis.

The Jewell Belting Company presented a souvenir to the members of the Association and others, that made the recipient feel wealthy at least for a short time. The memento consisted of a pocketbook with a bill inclosed that at first sight might be taken for at least a week's salary, but which on examination proved to be *not* one hundred dollars. The souvenir attracted much attention and was carefully put away for future use.

W. C. McKinlock, of the Enterprise Electric Company, Chicago, has been very industriously pushing N. I. R. wire and cables during the convention. Mr. W. H. Ferris, the manager of the St. Louis branch of this house, was also present at the convention and made many friends for this popular brand of wire.

Mr. J. K. Martin, representing Jas. J. Murray & Co., Philadelphia, had on exhibition a very fine line of glassware for electrical purposes. This company manufactures a full line of glass in the form of shades and globes in plain, opal and roughed, and also in various colors for both incandescent and arc purposes. Mr. Martin had on exhibition the largest line of samples ever shown by a house in this trade, and his rooms were constantly filled with central station managers and others interested.

The Eureka Tempered Company was represented at the convention by Jno. R. Coffman, who for some time has been stationed at Detroit. Mr. Coffman had a table in the east corridor at the Southern, on which he exhibited segments for all standard railway generators and motors, also segments and brushes for arc and incandescent work, together with a full line of sheet copper of all gauges and widths used by electrical people. The exhibit was a very handsome one and attracted much attention.

Mr. Garton, of the Garton-Daniels Electric Company, of Keokuk, Ia., was in attendance at the convention during the week. This company makes the Garton lightning arrester and other specialties. During the week this arrester was put on the Union Depot Railway circuit, and a test was made showing the ability of the lightning arrester to break the arc established by a short circuit on a line that carries from 1,000 to 1,500 ampères. The arrester instantly broke the arc thus established. This test was made without the throwing of the circuit braker or any interruption of the circuit. The railway people and all others who were cognizant of the work done were much pleased at the outcome.

Mr. S. E. Whitehead, of Carthage, Mo., who is manufacturing the Eddy patent self-locking windlass for raising and lowering arc lamps, was a guest at the Southern. Mr. Whitehead's appliance, which appers to be a very practical one, was shown in THE ELECTRICAL WORLD of Feb. 25. Correspondence addressed to the above address will receive prompt attention.

The Fort Wayne Electric Company exhibited the Wood alternating and constant potential lamp that apparently has many novel features. The lamp is simple in construction, there being but one point of adjustment in the whole mechanism. In this lamp the necessity for installing dead resistance boxes, fuse boxes and switches, it is claimed, has been entirely obviated, as all the devices are concentrated in a fireproof hanger board of novel construction. In installing the lamp it will be seen that the only requirements are to run two wires from the mains to the larger board and suspend the lamp. This to the central station manager saves not only the cost of the extra devices, but also the time of the workmen necessary to properly install them. So far as simplicity of construction and perfect feeding of the carbons are concerned, it leaves nothing to be desired. The humming sound when used on alternating circuits is considerably less than what would be produced by two carbons held across the terminals of a 50-volt transformer. This fact was clearly demonstrated by Mr. Wood in the presence of a large number of gentlemen at the Convention. The Ft. Wayne Company also exhibited a double alternating arc lamp which is presumed to be one of the first, if not the first, of the kind ever shown in this country. The exhibit was one of the largest at the Convention and attracted much attention.

The Electric Appliance Company made a neat display in the gentleman's parlor, exhibiting a line of Whitney instruments, swinging ball lightning arresters, Packard lamps. Acme expanding wire guards and attractive samples of Paranite wires, cables and switch cords and also a handsomely arranged sample case of "O. K." weatherproof wire samples. The company was represented by its secretary and treasurer, Thos. I. Stacey, and by its special agent, Mr. A. L. Millard, and was assisted by Mr. C. J. Butler, manager of the Indiana Rubber and Insulated Wire Company.

Among the many novel advertising schemes resorted to, the Electric Appliance Company will have to be given the first prize for originality. In addition to numerous circulars of its specialties and a small pamphlet of testimonials entitled, "What Others Think," which was attractive enough to deserve special mention, it kept their friends supplied with first-class cigars bearing the "Paranite" label, which is a sufficient guaranty that they were the best to be had. Its great strike, however, was the quill toothpick bearing the legend, "Electric Appliance Company. Electrical Supplies. Paranite Wire. Chicago." The dining room of the Southern Hotel was supplied with these during convention week, and each guest at the Friday banquet at the Jockey Club secured a package.

Mr. Edward Weston and Mr. R. C. Heinrichs, representing the Weston Electrical Instrument Company, of Newark, N. J., distributed exceedingly handsome pamphlets illustrating and describing the new Weston ammeters, voltmeters and other measuring instruments. They also exhibited the instruments themselves, including samples of the various parts, all of which attracted much intelligent attention. The Weston Company has now increased its facilities so that it can turn out a very large number of these instruments. For years Mr. Weston has given his undivided attention to this subject; and the success of the instruments manufactured by him, and the deservedly large sale they are meeting with, must be almost as gratifying to American electricians in general as to Mr. Weston himself.

Mr. E. Ward Wilkins, of the Partrick & Carter Company, was at the Convention to meet his customers among the delegates, and returned to Philadelphia by the Pennsylvania limited from Chicago on Saturday afternoon. The Partrick & Carter company is one of the oldest electrical manufacturing concerns in the country. With Mr. E. Ward Wilkins at the head of the factory, and his brother, Mr. C. M. Wilkins, in the business department, this old established firm has renewed its youth and is now doing by far the largest business that it has ever done.

The Portland Electric Water Power Plant.

What promises to be one of the most elaborate water power plants in the world is now in process of erection at Portland, Ore. It is put in for the Portland General Electric Company by the Stilwell & Bierce Manufacturing Company, of Dayton, O.

The Portland General Electric Company is a strong and ambitious corporation. It proposes to utilize the falls at Portland not only to make electric lights, but also to run a number of electric street railway lines and also to supply electric power to the citizens of Portland. Ten thousand horse power is to be generated in blocks ranging from 600 h. p. down. Twenty-two Victor turbines are to be put in at once—two 48-inch, ten 42-inch and ten 60-inch vertical cylinder gate wheels set in iron flumes and feeds.

The electrical plant will consist of ten 600-h. p. motors, ten 600-h. p. dynamos and two 400-h. p. exciters, made by the General Electric Company. The armatures, which go directly on the shaft wheel, measure 102½ inches, and weigh 16,000 pounds, and make 200 revolutions per minute. No belting of any kind will be used in the plant.

The waterfall has a head of 42 feet, but as at times the river has been known to rise so high as to considerably diminish this head, Mr. A. C. Rice, general superintendent and consulting engineer of the Stilwell & Bierce company, who prepared the plans for this important plant, has devised a very ingenious method of overcoming this difficulty by putting in a separate wheel to be used when there is a serious rise in the river.

Mr. P. F. Morey is president of the Portland General Electric Company; Mr. H. W. Good, manager, and Mr. H. H. Caufield, secretary. The Executive Committee consists of Mr. P. F. Morey, of Portland; Mr. H. M. Byllesby, of St. Paul, and C. A. Coffin, of Boston.

Practical Rules for Measuring Water Power.

In a recent communication Mr. Allan H. Foster suggests that the following might be added to the "practical rules" for the calculation of water power, given on page 160 of The Electrical World, March 4, 1893.

Horse power of water fall =1-11 (flow per second in cu. ft.) (fall or "head" in ft.).

This is at 80 per cent. efficiency, and with water at 62½ pounds per cubic foot.

NEW BOOKS.

LIGHTNING CONDUCTORS AND LIGHTNING GUARDS: A Treatise on the Protection of Buildings, of Telegraph Instruments and Submarine Cables, and of Electric Installations Generally, from Damages by Atmospheric Discharges. By Oliver J. Lodge, D. Sc., F. R. S., LL. D., M. I. E. E., Professor of Physics in University College, Liverpool; 544 pages; illustrated. London: Whittaker & Co., Paternoster Square, 1892. Price, $4.

This important work is the outcome of several lectures delivered by the author before the Society of Arts, in 1888, which attracted widespread attention on account of the radical views they contained, or, rather, the author implies, from radical deductions not justified by his views. In the volume the author treats the subject at length from various standpoints, corrects the misunderstandings that had resulted, and guards against future ones by reducing generalities to specific instructions. The experimental and mathematical sections are particularly interesting, as well as the resumes of the work of others, and of important discussions on the subject. A chapter is devoted to the description of lightning guards of the author's invention, and the subjects of iron versus copper conductors, the proper size and shape of conductors, earth resistance, etc., are treated in a masterly way. In a scientific work of this high character, and from the pen of such an acknowledged authority as Dr. Lodge, the chaotic arrangement of the contents of the book is, however, a matter of surprise, and sadly mars a work that will long remain as authoritative.

ENGINE ROOM CHAT. By Robert Grimshaw, M. E. New York: Practical Publishing Co. 1893. 144 pages, 11 illustrations. Price, $1.00.

This little book is another of the useful manuals by Robert Grimshaw, and contains a great deal of useful information for engineers, written in the inimitable style of the author, that renders his books very interesting reading aside from the sound practical knowledge they contain.

HOW TO MANAGE A DYNAMO: A Handbook for Ship Engineers, Electric Light Engineers and Electroplaters. By S. R. Bottone. London and New York: Macmillan & Co. 1893. 63 pages, plate and eight illustrations. Price, 60 cents.

This book is intended by the author for the use of engineers who find themselves suddenly called upon to undertake the management of a dynamo. The descriptive portions and text occupy 43 pages, and 17 pages are devoted to definitions.

"THE ELECTRICIAN" ELECTRICAL TRADES DIRECTORY AND HANDBOOK FOR 1893. Eleventh year. London: "The Electrician" Printing and Publishing Company, Limited. 600 pages of directorial matter, over 400 pages of handbook information. Price, $3.50.

With the present volume this admirable English Electrical Trades Directory enters on its eleventh year of publication, and has grown from the slim pamphlet of 100 pages of its first year to the present portly book of over 1,000 pages. The directory matter proper occupies about 600 pages and the remaining part of the volume is devoted to statistical and technical information and over one hundred pages of biographical sketches of the leading electricians of the world. To those having electrical trade connections with Europe this volume will prove invaluable, while the part of the book last referred to is of interest to the electrical public generally.

The W. J. Johnston Company, Limited, have in press the following books, which will be ready for issue within a few days:

THE ELECTRIC RAILWAY IN THEORY AND PRACTICE. By O. T. Crosby and Dr. Louis Bell. Second edition, revised and enlarged. 416 pages, 182 illustrations. Price, $2.50.

ALTERNATING CURRENTS: AN ANALYTICAL AND GRAPHICAL TREATMENT FOR STUDENTS AND ENGINEERS. By Dr. Frederick Bedell and Dr. A. C. Crehore, Cornell University. 325 pages, 112 illustrations. Price, $2.50.

ELECTRICAL MEASUREMENTS AND OTHER ADVANCED PRIMERS OF ELECTRICITY. By Prof. Edwin J. Houston, A. M. 429 pages, 169 illustrations. Price, $1.00.

ALTERNATING CURRENTS OF ELECTRICITY: THEIR GENERATION, MEASUREMENT, DISTRIBUTION AND APPLICATION. By Gisbert Kapp, with an introduction by William Stanley, Jr. 164 pages, 2 plates and 37 illustrations. Price, $1.00.

Put Yourself in His Place.

The following letter, which is self-explanatory, has been received from a kind-hearted and public-spirited gentleman who, like most other doers of good deeds, is unwilling that his name should be made public:

"After reading the letter from the life convict in the Dorchester Penitentiary, published in The Electrical World of Feb. 11, 1893, I must say that it has struck a tender cord in my pocket, and if The Electrical World is a pleasure and benefit to him, it would be a pity to deprive him of it. Enclosed you will please find postal note for $3 to renew his subscription, commencing with the date his expired, so as not to miss anything he might want to know. If there are any other responses to this "Voice from the Tomb," keep my offering for '94's subscription."

It might be added that the publishers of The Electrical World had already renewed this unfortunate's subscription for another year, so that he is now assured of the opportunity to gratify his interest in matters electrical until Jan. 1, 1895.

THE ELECTRICAL WORLD'S DIGEST OF CURRENT TECHNICAL ELECTRICAL LITERATURE.

(Compiled from the principal foreign electrical journals.)

BY CARL HERING.

UNITS, MEASUREMENTS AND INSTRUMENTS.

Units.—"L'Ind. Elec.," Feb. 10. publishes a translation of the complete report of the Amer. Inst. Elec. Eng. regarding the work of the Congress. It reserves its comments for a later number. It praises very highly the proposition to discuss the subjects before the Congress and merely decide them at he Congress. It does not approve of some of the definitions, namely, those for inductivity and for magnetic reluctivity; it does not approve of the term *voltage*.

Units.—"Industries" (Lond.) in referring to the researches of Mr. Volle, in which he found the temperature, of the arc constant, expresses the hope that the standard of light, proposed last year by Mr. Swinburne, will be adopted and come into general use.

Mercury Standards.—"L'Ind. Elec.," Feb. 10, gives an illustrated description of the new mercury standard of the German Imperial Physical Institute, accompanying the same by a description of the method of comparing them, and by a discussion of the temperature coefficients.

Temperature Coefficient of Mercury.—Mr. Guillaume has made very exhaustive tests to determine the coefficient of temperature for the resistance of mercury, and obtained the following results from 64 series of measurements between 0 degree and 62 degrees.

$$R_t = R_0(1 + .0008881\ t + .00009101\ t^2).$$

This, he states, agrees exceedingly closely with the results obtained by Messrs. Kréichgauer and Jaeger, of the German Physical Institution, from five mercury standards, between 14.7 degrees and 28.2 degrees, combined with those at 0 degree,

$$R_t = R_0(1 + .0008827\ t + .0000\ 126\ t^2).$$

The paper of Mr. Janet on the determination of coefficients of self-induction by means of electrical oscillations, referred to in these columns Feb. 18, may be found, presumably in full, in "L'Ind. Elec.," Feb. 10.

Meter.—A new meter in Germany consists of a soft iron bar capable of oscillating on a central axis; there are two coils, one wound transversely and the other parallel to the iron bar; the current is reversed periodically in the coil, which is parallel to the bar, by means of a polarized relay; the oscillations of the iron bar are somewhat like those of the escapement wheel of a watch, and its motions are transmitted to a set of integrating wheels as usual.

Photometry.—Mr. Henry, before the French Academy of Sciences, stated that between sufficiently wide limits and, therefore, under conditions easily realized, the quantity of light emitted by phosphorescent sulphide of zinc is independent of the time of illumination as well as of the thickness of the layer or the distance to the magnesia lamp; it therefore is especially well adapted for a secondary standard in photometric work. In experimenting with these substances he also found that the smallest illumination perceptible to the human eye was equal to 29×10^{-9} candles at one metre.

Practical Rules.—Several correspondents of the Lond. "Electrician" contribute a number of approximate practical rules, among which are the following:

To reduce centimetres to inches, multiply by .4 and deduct one inch in every five feet. To reduce metres to yards, add one-tenth, deduct one-tenth of this correction and add one-third of the last correction. To reduce kilometres to miles, multiply by .6 and add one mile in every thirty.

To ascertain velocities in miles per hour, take any convenient distance in yards, measure the time, divide the yards by the seconds and multiply by two; this will give the miles per hour approximately.

A horizontal belt one inch wide, running at ten feet per second, will transmit one horse power if the pulleys are not too small; an increase of width or speed will transmit a proportional increase of power.

A pipe one inch in diameter holds one pound (or .1 gallon) of water in one yard running; the capacity of a yard of any pipe in pounds may therefore be represented by its diameter in inches squared; for greater accuracy, add one-fiftieth. To find the capacity of a cistern, remember that eight cubic feet contain 500 pounds, or 50 gallons, of water.

The resistance of any wire is the length in feet divided by the cross-section in square inches and multiplied by .000008. For greater accuracy add 10 per cent.

For finding approximately the current in a wire, place it parallel to the magnetic meridian, place a small watch charm compass vertically under or over it and move it until the deflection is 45 degrees, then the distance from the needle to the wire in centimetres multiplied by .9 is the current in amperes. If the deflection is 48 degrees it is not necessary to multiply by .9.

DYNAMOS, MOTORS AND TRANSFORMERS.

Alternate Current Motors.—Mr. Arnold, of the Oerlikon Company, in a letter to the English journals, refers to the alternating current motor of Brown, described in these columns in the issue of Feb. 25, and states that early in 1892 that company had already constructed a series of motors of standard types from one-eighth to 9 h. p. for ordinary single phase currents running non-synchronously, the efficiency being nearly equal to that of multi-phase motors. The article seems to show that Brown was anticipated by that company. He appears to claim that Brown merely uses the methods of Elihu Thomson and Tesla. Small motors, he says, can be started by hand by pulling on the belt. Another method is to divide the inducing winding into several sections and connect them with the segments of a current reverser, built up like a collector, and fixed on the switchboard; by means of a hand-wheel and double brush contacts sliding on the segments of the current reverser a rotating field is produced, which will start the motor; the motion of the brushes on the current reverser can then be stopped in any position. He states that the methods shown in Figs. 3, 4 and 5 in The Electrical World, Feb. 25, p. 129, were devised by Tesla; and that the method of winding the armature like that of a continuous current machine, the commutator of which is afterward short-circuited, was invented by him (Arnold), which he substantiates by quoting an extract from his patent specification; this quotation leaves no doubt that the invention is the same as that described by Mr. Brown.

Mr. Guy in his serial, in the Lond. "Elec. Eng.," intended for students, shows and illustrates how to calculate the ampere turns required for the field magnets of a dynamo. This serial is in the nature of a textbook giving a general summary of the subject.

Measuring Efficiencies.—A correspondent of the Lond. "Electrician" suggests measuring the efficiency of a dynamo by first measuring the volts and amperes and then measuring the power lost by the fall of speed of the dynamo when the driving power is suddenly cut off. He gives a formula for calculating the lost power from this fall of speed. Although interesting and simple on paper, it can hardly be said to be a practical method.

Brushes.—Regarding the brushes, mentioned before in these columns, made of exceedingly fine foil, Mr. Gerard, in "L'Electricien," states that besides the qualities pointed out, these brushes have the additional advantage of preventing sparking, for the following reason: In a laminated brush the current from the short-circuited coil must pass through one lamina back to the far end of the brush, where they are soldered together, thence back to the next segment of the commutator; it does not pass directly across from one foil to the next on account of the resistance of contact due to the layer of oxide on the surface. Each current from the short-circuited coil, therefore, encounters sufficient resistance through these fine laminae to materially diminish the spark; the thinner the lamina the better the effect. The same thing was formerly accomplished by connecting the coils to the commutator bars by means of german silver wires. Carbon brushes also accomplish this to some extent, but they are very apt to heat. The foil brushes also have the advantage that they do not vibrate, and, therefore, do not produce an uneven surface on the commutator.

The ring oiler, so frequently used for dynamos, is stated to have the disadvantage of throwing the oil off by centrifugal force. To obviate this, Mr. Henrion provides the ring with a number of cavities which enables it to bring the oil up to the top where it is spread over the bearing. Lond. "Electrician," Feb. 17, gives a cut of this modification.

Transformers.—Dr. Fleming replied at great length to the criticisms of his recent paper, reprinted in the recent issues of The Electrical World. He maintained that facts showed that the best open-circuit transformer produced is not better than the closed circuit. In a set of tables he showed that both the Hedgehog and Mordey transformers gave an all-day efficiency of 79 per cent. on a 10 per cent. load factor. The all-day losses in a one-mile cable for 4 transformers, for the Hedgehog, gave 2,66 kilowatt hours, and for the Mordey, only .438; the saving would pay for a good many Hedgehogs; he adds that one could afford to throw them away and buy others. He calculated the cost and maintenance of high and low pressure feeders at one mile, showing that the former can be put down for half and maintained for less; the latter would also require a much larger generating plant; the relative loss also increases in the low pressure mains as the load factor increases. The direct current system was not efficient over one mile. He hoped the time of beliefs was now left for that of facts and exact calculation. Dr. Fleming's reply will be found abstracted in the "English Notes" in the present issue. This reply, which forms the most interesting part of the discussion, may be found, presumably in full, in the Lond. "Electrician," Feb. 17, p. 453. It is also editorially commented upon, at considerable length, in the same issue. The Lond. "Elec. Rev.," Feb. 17, p. 198, also contains a portion of this discussion, and the Lond. "Elec. Eng.," Feb. 17, an abstract on page 171. This paper and its discussion is probably the most interesting and important contribution on the subject of transformers which has ever been made, and its careful study is recommended to all those interested in the subject.

ARC AND INCANDESCENT LAMPS.

Electric Light vs. Gas.—In the serial on electric light and gas, Mr. de Segundo, in the Lond. "Elec. Rev.," makes a comparison for a particular installation of 1,500 lamps of 8 c. p. burning 1,500 hours per year. He works out the cost of the light and finds that the gas engine plant comes first in point of economy; gas burnt direct is about 1½ times as expensive, and electricity from central stations, at 14 cents per kilowatt hour, is about 3½ times as much; this does not include lamp renewals or interest and depreciation of the wiring and fixtures. He concludes that an installation of 1,000 lamps of 8 c. p. is the lowest limit of size in which a private pant is more economical, where gas costs 75 cents per thousand and electricity 14 cents per kilowatt hour. Regarding current from the most economical primary batteries, he says the cost is 50 cents per kilowatt hour. He also makes a comparison of the cost of electric heating. (As so little is known regarding the efficiency of coal heaters, such theoretical calculations are worse than useless.)

In the Lond. "Elec. Eng." Mr. Crowe questions Mr. Walker's figures on the cost of arc and incandescent lighting. A 2,000-c. p. arc lamp, taking 15 amperes and 60 volts, at 12 cents per kilowatt hour, allowing one-half cent per hour for carbons, when compared with eight 200-c. p. incandescent lamps at 400 watts each, and 2½ cents for lamp renewals, shows that the latter costs four times as much as the arc light.

"L'Ind. Elec." gives an illustrated description of a small switch for incandescent lights, which contains a ring of carbon connected to a number of contact blocks, for the purpose of diminishing at will the intensity of the light and at the same time to avoid turning on the lamps too suddenly, claiming that thereby the life of the lamps is prolonged; it also acts as a cut-out.

The Lond. "Electrician" says of the new Westinghouse lamp: "It appears highly improbable that this lamp will be able to compete with lamps made in the ordinary way."

TRANSMISSION OF POWER.

Prof. Unwin's fifth lecture is reprinted in the Lond. "Electrician," Feb. 17. It is devoted entirely to the subject of pneumatic transmission. As it is not electrical, it will not be abstracted here. He states that compressed air was the most formidable rival of electrical transmission. For ordinary power purposes, excluding the application of power for transit and lighting, he states that enormously more work was being done by compressed air than by electricity. He states that at present there was no case where power was distributed by the alternating current system. (In this, however, he is mistaken.) He states that power distribution in towns, when not a subordinate function of an electric lighting plant, could be more economically and efficiently effected by compressed air than by electricity. (Although Prof. Unwin is a recognized authority on mechanical power transmission, we fear this last statement indicates that he is not an authority on electrical transmission.)

In "L'Ind. Elec." Mr. Arnoux gives the theory of a proposed apparatus for measuring directly and automatically the power of machines. He says the usual apparatus measures the work, while often it is desired to measure the power directly. To the usual apparatus for recording the power transmitted, he proposes to add another which introduces the element of speed in such a way that the final result will give the power transmitted.

Liverpool Railway.—The Lond. "Elec. Rev.," Feb. 10 gives a short description of this interesting railway. The greater part of it is devoted to the civil engineering features, though some of the cuts also show other features. The article is illustrated with 12 excellent half-page illustrations and three smaller ones. In addition to what was said last week in these columns, the following may be of interest. The generating station is about in the middle of the line; there are six boilers 30 feet by 8 feet for 120 pounds pressure, having mechanical stokers; the coal comes from overhead. There are four horizontal, coupled, compound engines, each of 400 h. p. at 100 revolutions, having Corliss valves; the flywheels are 14 feet in diameter, and are grooved for 19 ropes of 1¼ inches; independent condensing apparatus is used. The steam and feed pipes are arranged for a duplicate

service; the engines may also exhaust into the air. There are four shunt wound dynamos for 475 amperes and 500 volts at 400 revolutions, having double vertical horseshoe magnets; the latter are divided on a horizontal line so that the upper half can be lifted off to allow the armature to be examined. All the dynamos are coupled in parallel on the omnibus bars.

The conductor consists of a steel channel carried between the rails, and shown in the cut, Fig. 1, which explains itself. The top of the conductor is about an inch higher than the rails. The crossing of a conductor and a rail is shown in the cut, Fig. 2. The motors on each train of two cars are on the leading and the trailing truck; they are gearless; 10 revolutions per minute give a speed of one mile an hour; the maximum speed is about 26 miles an hour, making 260 revolutions of the motor per minute. The motors are series wound; tested with a brake they gave a torque on a wheel 2.9 feet in diameter as follows: For 30, 50 and 80 amperes, 170, 450 and 1,060 pounds. The two motors, one at each end of the train, are both controlled by the driver, who is always at the front end; he has a key, without which the motors cannot be operated. A loaded train weighs 40 tons. Compressed air tanks for the air brakes are charged once for each journey; the same system is used on the City &

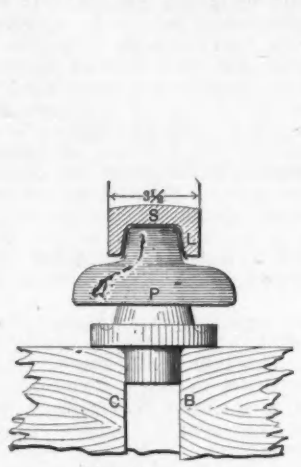


FIG. 1.

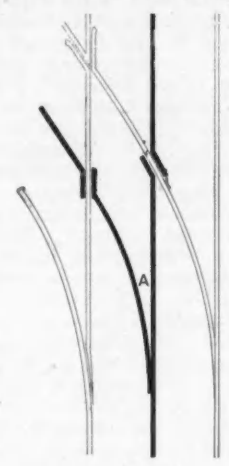


FIG. 2.

South London Railway. The trains will run at five minute intervals, but the capacity admits of three minute intervals; the whole journey, including stops, takes less than half an hour; there are 13 stations along the docks. An experiment is to be made with automatic signals. The total cost, including equipment, is about $425,000 per mile.

Friction Gearing.—The Lond. "Elec. Eng." calls attention to the fact that a locomotive drives by simple friction on the rail, and suggests that, therefore, a motor might drive the wheel by simple rolling friction. It mentions a device of Siemens & Halske for driving in this manner. The difficulty lies in overcoming the effect of vibration. The device is, unfortunately, not described, but it is probably very simple.

INSTALLATIONS, CENTRAL STATIONS, SYSTEMS, ETC.

Grounding the Neutral Wire.—Mr. Picou, in a paper on this subject before the Internat. Soc. of Electricians, calls attention to the fact that experts' opinions differ very greatly; he states that the problem must be considered from two different standpoints. First, to avoid fire due to short circuits, and, second, to avoid electrolysis due to leakage. To avoid the former the possible difference of potential between any of the circuits and the earth should be made as small as possible; this is accomplished in the three-wire system by grounding the neutral wire. In a simple double-wire system this can be accomplished by creating a neutral point. This he proposes doing by the use of a compensator, formed by [illegible] connected in series between the mains, their junction point being then grounded through a fusible plug; it can also be accomplished by grounding the middle point of a battery connected between the circuits.

To avoid electrolysis by leakage, the negative pole should be grounded, as it is the positive one which is attacked and dissolved by the electrolytic action. He states that it is bad practice to use bare wire for the grounded neutral. The conditions to avoid both of these injurious effects are, therefore, not the same. He states that it is very important to make the earth connection at only one point, as also to verify the ground connection frequently. He claims it is a mistake to suppose that gas pipes give a good ground; water pipes are very much better.

Mr. Bochet, in discussing the paper, states that it is important in a three-wire system to ground the neutral wire in order to avoid a possibility of an increase in the difference of potential of the lines on the other side; he states it should be connected to earth through a cut-out. For an abstract of the paper see "L'Ind. Elec.," Feb. 10.

Municipal Contracts.—Mr. Gibbings, in the Lond. "Elec. Rev.," Feb. 10, in a short article on this subject, calls attention to the objections and evils of the present systems of making such contracts. He suggests that municipal authorities ought not to deal with electrical undertakings in a piecemeal fashion, and that they should have a wholesome distrust of their own competency as individuals; they should raise such matters above the level of a mere mechanic's job. He advises them to obtain the services of a competent electrical engineer from the start and not after a contract has been awarded; they should avoid taking the advice of a one-sided and interested consulting engineer. To employ an electrical engineer after a contract is awarded, he says, is not only unfair to him, but also to the public. He speaks of advertising for proposals by merely giving the probable requirements; but as such bids are so different they are difficult to compare; the matter is left to the decision of an electrical expert. The paper is devoted to finding fault rather than to suggesting remedies.

Cost of Producing Electricity at Central Stations.—"Lightning" (London) gives same tabulated information on this subject for the principal English central stations. The table contains quite a large number of items, into which the cost is divided. It is not of a nature to admit of being abstracted.

The Lond. "Elec. Eng." mentions the fact that a Mr. Zakihian has invented a device for increasing the steaming power of boilers, consisting of a simple apparatus to be slipped into the tubes; no description, however, is given. What are said to be reliable tests have been made at the Deptford station, which show an economy of 25 per cent., which is certified to by presumably reliable authority.

Systems.—"L'Ind. Elec." contains a discussion regarding the priority of invention of the transformation of a constant alternating current into one of constant potential.

Central Stations.—"L'Electricien," Feb. 11, contains a description of the new alternating current station in Zurich by Dr. Palaz; it is illustrated with a complete ground plan and several views of the machinery. This installation is probably one of the largest and finest alternating current installations in the world. It is driven entirely by water power.

"L'Ind. Elec.," Feb. 10, gives a short description of the station at Barnen, Austria, in which accumulators are run in parallel with the dynamos. This was one of the first stations erected on this plan.

The Lond. "Elec. Rev.," Feb. 17, gives a short description, including numerous details, of a light and power plant in Benatek, Bohemia.

WIRES.

Impurities of Copper Wire.—Mr. Hampe gives the following results of experiments made by him with carefully purified copper, alloyed with other metals. For further information see "Chem. Zeitung," vol. 16, p. 726:

	Relative conductivity.	Tensile strength in lbs. per sq. in.
Pure copper	100.00	49,200
With .216% arsenic.	61.05	59,100
" .351% "	50.15	72,600
" .808% "	29.96	69,500
" .260% antimony.	68.07	72,900
" .529% "	56.50	78,000
" .526% silicon	28.11	71,100
" 3.472% "	6.50	135,500

ELECTRO CHEMISTRY.

Copper Tubes and Wires.—"L'Ind. Elec.," Feb. 10, contains a short description for the manufacture of copper tubes by the process known as the Picard et Taniere. In a well known process, invented by Mr. Elmore, the copper is deposited electrolytically on a revolving cylinder, on which burnishers of agate are made to act, so as to avoid a crystalline formation of the copper deposit and giving it a fibrous texture. In the present process the agate burnishers are replaced by agate hammers which are operated electromagnetically. The hammers travel longitudinally as the cylinder rotates, the speed being regulated as desired, as is also the stroke of the hammer. The core on which the copper tube is deposited is made of copper coated with plumbago. The article gives a table containing the sizes, speeds, current rapidity of the blows, etc., which have been determined from practice. For making wire in this manner the copper tube is made two millimetres thick, and is afterward cut spirally, forming a continuous wire of square cross-section which is afterward driven to any desired diameter. The specific resistance at 0 degree is 1.6158 microhm-centimetres. The advantages claimed are the rapidity of manufacture and the good quality of the metal.

The electrolytic purification of mercury, mentioned last week, is conducted as follows: The vessel is shown in the cut, Fig. 3; it is about 19 centimetres in diameter; a is the anode and b the cathode; the leading-in wires are of platinum; the density of current is about .012 ampere per square centimetre for the cathode and .003 for the anode. The liquid surrounding the anode becomes concentrated, and, in order to mix it automatically with the other, the cathode is placed lower, as shown, making a continuously running apparatus.

Primary Battery.—"L'Electricité Pour Tous" describes the new battery intended for medical purposes. It consists of a large cylindrical block of carbon having numerous holes bored into it parallel to its axis. These holes are packed with binoxide of manganese, which can be removed when exhausted and replaced by a new charge; the carbon acts as a porous cell and at the same time as the electrode; the other pole is a rod of amalgamated zinc; the electrolyte is a solution of chloride of zinc, free from lead and as neutral as possible, having a density of 20 degrees. The E. M. F. is 1.5 volts; it is suitable for open as well as closed circuits. The product is oxide of zinc, which falls to the bottom of the cell. There is no crystallized deposit formed on the zinc. Another modifi-

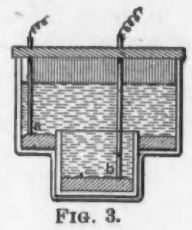


FIG. 3.

cation is to make the retaining cell of a hollow cylinder of dense carbon; a porous jar is placed inside of this and the space between the two filled with the manganese compound while the zinc is placed in the porous cup.

Accumulators.—The Lond. "E'ectrician," Feb. 17, gives several illustrations of the application of small accumulators to the lighting of lamps in the London omnibuses. This method of lighting has been in use for some time and is stated to be very satisfactory. The battery weighs 8 pounds; the lamp is so suspended that it is not injured by the shaking of the omnibus. It also illustrates a small pocket accumulator and a buttonhole lamp used for the past year by the ticket inspectors of the London omnibuses.

Specific Weight of Peroxide of Lead.—Mr. Kirchknop in the Lond. "Elec. Eng." is reported to have made tests with a large number of cylinders of peroxide taken from plates after four years' of service. The cylinders were crystalline in structure. The specific gravity of the peroxide, fully charged, is 7.75 without taking into account the pores; the weight of the same mass with the pores filled with air is 4.66.

MISCELLANEOUS.

Magnetic Clutches.—In "L'Ind. Elec.," Feb. 10, Mr. Picou describes some of the practical results of the experiments of M. De Bovet for the application of magnetic adherence. The first application described is that of a wheel on board of river vessels for driving, by pulling on a chain lying in the bottom of the river—a method used quite frequently in Europe in rivers having strong currents. The iron chain passes over an iron wheel in

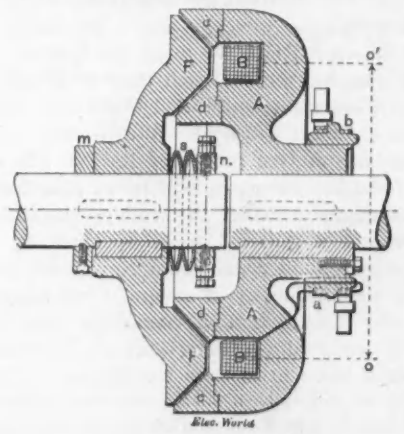


FIG. 4.

the form of a circular magnet, the magnetic circuit of which is closed by the iron chain, which passes in a groove in its periphery; the current is passed through a coil contained in the wheel itself. In the old method, which relied on simple friction, great lengths of the chain were required around the driving wheels in order to obtain the required friction. Experiments prove this magnetic method to be far superior, and it is at present being introduced. The article contains a cut of the wheel.

A second application mentioned was that of clutch coupling, to replace the usual friction or grip clutches. The apparatus is shown in the accompanying cut, Fig. 4, which explains itself; notice should be taken of the fact that the piece F must have a slight axial motion; also that the surface of contact is conical and not flat, which is a matter of great importance, as it gives the maximum effect and allows of slipping in case this effect is exceeded, thus protecting the apparatus driven from being injured by an excess of power; flat surfaces, he claims, do not give this same result. For transmitting 400 to 500 h. p. at a moderate velocity, a clutch 3 feet in diameter is required.

Another application mentioned and illustrated is an

arrangement for braking a train of cars. A separate brake wheel in the form of a circular magnet is attached to the axle, having a conical opening in the magnetic circuit, into which fit a number of iron wedge-shaped pieces attached to a steel band; the brake wheel contains the coil for the current, and the iron wedge-shaped pieces close the magnetic circuit formed by the air gap. Among other advantages are the cheapness of the apparatus and the small amount of energy required. The braking blocks embrace the wheel from 180 to 270 degrees. The braking power is said to be very great, and it is operated very easily. By simple arrangements it can be made automatic in case the train parts.

Engraving by Electricity.—According to a German paper the design is drawn or photographed on the plate of zinc, covered with a layer of bitumen; the plate is then placed in a bath and connected to the battery. A few minutes suffice to obtain the required depth, which can be regulated with mathematical accuracy. The great advantage of this process over simple etching is that, in the latter, bubbles of gas are produced which adhere to the plate, making the outlines irregular, and therefore necessitating frequent removals and brushing; in the former no such gas bubbles are formed and the action is much more regular and rapid.

Electric Furnaces.—Mr. Moissan, in an electric furnace of limebricks, obtains a temperature of 3,000 degrees C.; the highest temperature previously obtained in the oxygen furnace is stated to have been 2,000 degrees; at 2,500 degrees lime, strontia and magnesia crystallize in a few minutes; at 3,500 degrees the walls of the furnace melt.

Heating Iron Rods for Nail Making.—Mr. Siemens, in a lecture before the Royal Institution, describes a very interesting electrical furnace for the manufacture of horseshoe nails. It consists of a huge core of carbon made incandescent by a large current of low voltage; the core is hollow and is embedded in sand to prevent the escape of heat; the iron rod to be heated is passed slowly through this core, becoming red hot instantly, the heat being regulated by the speed with which it was passed through. It has proved itself excellent for tempering springs and was also used for heating rivets. It has the great advantage of being very easily manipulated and being quite portable.

Speed Counter.—The English journals contain illustrated descriptions of a speed counter, made in the external form of a pocket watch with a dial on each side having each two hands pointing to the number of revolutions; it is direct reading whichever way the machinery revolves, as the two faces are graduated in opposite directions; the pyramidal point which is inserted in the end of the shaft takes the place of the usual milled head nut of a stem winding watch.

Electrical Progress in Philadelphia and Elsewhere.

BY HENRY G. ISSERTEL.

Philadelphia—the "Sleepy City!" But from the standpoint of the electrician, the good, old Quaker stronghold certainly does not merit its old time sobriquet, as to-day it is one of the most active and thoroughly wide-a-wake centres in the electrical field. With preparations on foot to change the motive power of its 278 miles of street railway from the present use of horse and cables to that perfection of rapid transit, the trolley—the contemplation of a new line of railroad, to be operated by that same system, which shall reach from New York to Philadelphia—the establishment of several rival telephone companies, and the erection of numerous light and power plants—it can hardly be seen that the electrical fraternity, at least, have little time for slumber.

A short time since a large number of representative manufacturers and dealers in all that pertains to the electric road of to-day, met at the office of the Philadelphia Traction Company, for on that day it was expected the various contracts were to be awarded. Some idea of the unusual size of these contracts may be obtained by noting the fact that the order for trolley insulators alone called for 20,000, aside from all other appliances. Who the lucky ones were has not been learned, but it is understood that the majority of the car equipments went to the Westinghouse Manufacturing Company, of Pittsburgh, Pa., as was originally intended. But this system will not be used exclusively. The work will begin, as soon as the weather permits, on all lines at once, and it is confidently expected that it will be complete, in the main, if not entirely, by next fall.

A syndicate has been formed by a number of Philadelphia capitalists, who are now getting bids for the survey for an electric road to reach from Philadelphia to New York City. The power will not be furnished by the usual mode of central distribution, but from a station at each end of the line; and it is expected that the route will be much more direct than any in use to-day. An excellent idea is the thorough duplication of engines, boilers and generators at each station, to avoid shutting down in case of accident and the consequent delay.

They expect to attain a speed of from 75 to 90 miles an hour, which will reduce the regular running time over one-half. The intention is to make this solely a rapid transit line between these two cities, as no freight of any kind or description will be carried, and only the regulation "150 pounds of wearing apparel" will be permitted each passenger. Three tracks will be laid—two for the through trains and one for the "local." It is expected that this idea of rapid transit will greatly recommend itself to the suburban residents of both cities, and will greatly increase the value of property along the line.

A promoter of this scheme told the writer that they also proposed to erect a line of poles, to carry a number of metallic circuits; these lines to be rented to firms and corporations who had offices in both cities for private telephone lines. However, telephone instruments will not be furnished by this corporation, as it is confidently expected, that immediately upon the expiration of the patent now protecting them, each subscriber will supply himself with a complete outfit.

I made a tour of the various stations recently, and was surprised at the remarkable increase of capacity in nearly every station. Since I saw them in January, 1892, some have increased their capacity over 100 per cent., and some companies have been compelled to erect new stations to meet the demands of new business. The two most worthy of note are the Powelton Electric Company, of West Philadelphia, whose beautiful structure is a credit to the city, and the Northern Light and Power Company, of Kensington. The remarkable extent to which the use of electric lighting in private houses is being carried in this section of the city, is one cause of the enlargement of the former station. It is now, like the East End Electric Light Company, of Pittsburgh, devoted almost exclusively to the illumination of private residences.

The pole an line work, radiating from the new Northern station, at Kensington, is the finest pieceof aerial construction work the writer has ever seen. It reminds one of the long distance telephone pole line running through 110th street, New York City.

In response to an invitation from the Westinghouse Electric and Manufacturing Company, of Pittsburgh, Pa., to be present at the exhibition of the dynamos now building for the lighting of the World's Fair, I made my way to the old air-brake works, on Robinson street, upon my last visit to the "Smoky City." It was truly a great sight to an electrician to view the magnificent machines with their capacity for 15,000 16-c. p. lights with the 1,000-h. p. engines attached, the weight of each machine alone amounting to 150,000 pounds. The armatures, the largest single piece of the dynamos, will alone weigh 42,000 pounds.

To intelligent thinkers from every part of the world the sight of these triumphs of mechanical and electrical skill will prove one of the most interesting features of the Columbian Exposition. The fact alone that this plant will exceed in capacity any station in the world will prove a marvel to the dullest mind, while to those interested in the rapid strides of electricity in the nineteenth century, this remarkable evidence of its growth will prove most absorbing. This company will have, at the great building set apart for machinery, an exhibit of long distance power transmission, with its generators and motors, all the recent inventions in the field, with numerous interesting illustration of scientific phenomena. This exhibit will be supplied with power from the great dynamos, which have been designed to give multiphase currents for the operation of the Tesla motor, as well as for the illumination of the immense buildings. It is expected, by the way, that nearly 300,000 lamps will be required at the opening of the fair, with a daily renewal of 1,000. A model lamp factory is, I am told, to form a part of the exhibit, which will make new lamps as well as construct carbons for the new stopper incandescent lamp.

Institution of Electrical Engineers.—III.

NAUGURAL ADDRESS BY WILLIAM HENRY PREECE, F.R.S. PRESIDENT, DELIVERED JAN. 26, 1893.

X.—ELECTRIC TRACTION.

The use of electrical energy for working railways is making gigantic progress in the United States, and has commenced to make a serious move in the United Kingdom. The City & South London Electric Railway has proved a decided success, and next week will record the opening of a still larger enterprise on the elevated railway of the Mersey Docks, in Liverpool. When I last visited America, in 1884, there was only one electric railway in work, and that was in Cleveland. One company alone, the General Electric Company, of the United States, working the Thomson-Houston systems, has now: Roads in opration and under contract, 440; cars, 8,856; miles of line in opration, 4,628. Thus the average length of electric railway is 10.5 miles, and the average number of motor cars in use about two per mile. The power used is over 100,000 h. p. Speeds of 40 miles an hour are sometimes obtained in the open country, but in the crowded streets this rate is much reduced.

In 1892 there were 250,000,000 passengers carried 50,000,000 car miles run. The capital invested in such railways is £12,000,000, and the cost for working comes out at 6d. per car mile. All these railways are worked with overhead conductors, by what are known as trolley lines. Such a line is at work in Leeds, and the South Staffordshire tramways have just started the same practice.

Considerable experiments have been made to work tramcars by accumulators carried on the car. They have not met with much success, owing to the cost of renewals. The Birmingham Central tramways are, however, persevering in this direction, and they are now giving an extensive trial to a new form of accumulator—the Epstein—the proprietors of which have adopted the novel plan of undertaking to renew the accumulators at the rate of 1½d. per car mile.

XI.—THEORY.

In the presidential address which I delivered to the Society of Telegraph-Engineers and Electricians, in 1880, I took the opportunity to formulate the theoretical views of electricity that I had acquired at the feet of Faraday. It is not given to every boy to have his great ambitions realized. One of my ambitions as an earnest listener to Faraday's simple and delightful lectures was to be his assistant, and in almost the last investigation he undertook on electric induction in underground wires it was my privilege to see much of him, and to prepare many experiments for him. Early in 1854, at his wish, I carried out for Mr. Latimer Clark certain experiments on the comparative effect of increments of voltage in increasing the rate of transmission of signals through long telegraph circuits. It was found that variation of voltage had no effect. Currents from 31 and from 500 cells sent through 768 miles of gutta-percha covered underground wire showed precisely the same velocity. These experiments were sent by Faraday to Melloni, who had prompted the wish, and Melloni ("Faraday's Researches," vol. iii., page 577) remarked: "The equal velocity of currents of various tensions offers a fine argument in favor of the opinion of those who suppose the electric current to be analogous to the vibrations of air under the action of sonorous bodies." This is to be found in the very last contribution inserted in the greatest work ever published on our science, "Faraday's Experimental Researches in Electricity."

Faraday's views were subsequently expounded and extended by Maxwell, who said: "Faraday, in his mind's eye, saw lines of force traversing all space, where the mathematician saw centres of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids" (Maxwell's "Electricity," vol. i., page 10).

Since that period I have never regarded electricity as anything else but as a form of energy, and its effects as modes of motion of the molecules of matter and of the ether that fills all space; and during my long apprenticeship of 40 years I have never examined one experiment or considered one fact that was not explicable on this theory.

It must be distinctly understood that I apply the term electricity to that form of energy which we as engineers utilize in the service of man. I do not apply it, as some physicists do, to a mere imaginary factor of this energy, sometimes called "quantity," and even honored with a unit—the coulomb. I use it in the same sense that we use the terms light, heat and sound, which are universally acknowledged to be forms of energy. In my address as President of the Mechanical Section of the British Association at Bath, in 1888, I pointed out the great confusion that arose from this misapplication of terms, and I suggested that the disturbing factor—the vague subjective unreality of the physicist—might be called by some other term. I now go further, and suggest that the term be abolished altogether. We can do without it. It is not wanted. We have excluded the coulomb from our new legal system of C. G. S. units.

The electricity of the engineer is a definite form of energy. It has one objective reality that we can generate, utilize, measure, and sell. It is even regulated by Act of Parliament. It is, moreover, "understanded of the people."

The tendency of modern practice is to import simplicity into theoretical inquiries. True theory does not require the abstruse language of mathematics to make it clear and to render it acceptable. The doctrine of evolution, the principle of the conservation of energy, the undulatory theory of light, the thermal equivalence of work, the development of electrochemical transformation, and all that is solid and substantial in science and usefully applied in practice, have been made clear by relegating mathematical symbols to their proper store place—the study.

The doctrine of the conservation of energy implies that energy, like matter, cannot be created or destroyed. Its form only can be changed. Its total value always remains the same, and we can always measure it when all the different forms in which it exists in the particular system are taken into consideration. There has been no more fruitful principle introduced into science during this century than the equation of energy, which implies that the total energy of every physical system is the sum of all the energies of its different parts, whether usefully or uselessly expended.

Maxwell said: "The special work which lies before the physical inquirer is the determination of the quantity of energy which enters or leaves a material system during the passage of the system from its standard state to any definite state."

Every molecule at any instant of time is in one place only, and any change of its position during any interval of time is the result of force applied, and is effected along a continuous path and in an orderly manner. The laws governing the mode of motion, and determining the direction, magnitude and nature of the work done, are the objects of physical research.

The molecular theory of electricity, which regards it as a form of energy, supplies the physicist with a powerful weapon to combine in one great science of "energetics" all physical phenomena. Maxwell, had he lived, would probably have accomplished this. He raised a superstructure upon the foundation stones laid by Faraday. He annihilated action at a distance, he established the existence of stresses and strains in the

* For the previous sections of this paper see THE ELECTRICAL WORLD of Feb. 18, 1893, p. 125, and Feb. 25, 1893, p. 141.

ether, and he showed the identity of luminous and electromagnetic waves.

Subsequent experiments have confirmed his views.

Electricity is, therefore, energy which is transmitted by matter and through space by certain disturbances the result and equivalent of work done, and in certain orderly and law-regulated forms, called "electromagnetic waves." It is not difficult to conceive the ether curved or the molecules of matter swayed or excited in definite periodic waves. A molecule is subject to all kinds of motion—translation, oscillation, rotation upon its own axis, and revolution about some external axis. Clausius (Pogg. Ann., clvi., p. 618) suggested that the atoms or groups of atoms constituting a molecule revolve around one another similarly to planets, and are sometimes nearer to and sometimes further from each other. The difference between the infinitely great and the infinitely little, is only one of degree. The motions of the solar system and that of a molecule of water are similar. These motions are imparted to and transmitted by the ether, and they are taken up again by matter. One kind of wave gives us light, another radiant heat, another magnetism, and another electrification. The rate at which these waves move is the same, viz., 30,000,000,000 centimetres, or 192,000 miles, per second. It is only their form and their frequency that differ. Matter and ether are subject to strains, currents, vortices and undulations, and every single electromagnetic phenomenon can be compounded of or reduced to one or other of these mechanical disturbances. Rotation in one direction gives positive electrification; rotation in the opposite direction gives negative electrification. A whirl in one direction gives us North magnetism; in another direction, South magnetism. Hertz, the experimental exponent of Maxwell's views, has shown the existence of electromagnetic waves, and has proved their reflection, refraction and interference. The rate of their propagation is the same in ether, air and conducting wires.

The most recent discoveries and deductions are all in accordance with this mechanical theory. J. J. Thomson's views that at high temperatures, in the act of dissociation, all gases, and Dewar and Fleming's conclusion that at low temperatures—in fact, at the absolute zero of temperature—all metals become perfect conductors, might almost have been predicted. Hysteresis and Foucault losses are mere wastes of energy, due to molecular friction or to internal work done on the molecules, assisted by bad design and impure material; but, being measurable and comprehensible, their reduction to a minimum has become possible and actual.

It is a misfortune that a beautiful hypothesis like Maxwell's electromagnetic theory of light has been discussed almost solely by mathematicians. Its consideration has been confined to a small and exclusive class. It has not reached the public; and this is to be regretted, for, after all, it is the many, and not the few, that determine the acceptance or refusal of a theory. The existence of the ether is now thoroughly comprehensible. Light is now regarded as an electromagnetic disturbance. The eye is an extremely sensitive and delicate electromagnetic instrument. The difference between luminous, thermic and electromagnetic waves is one of frequency and form.

(To be continued.)

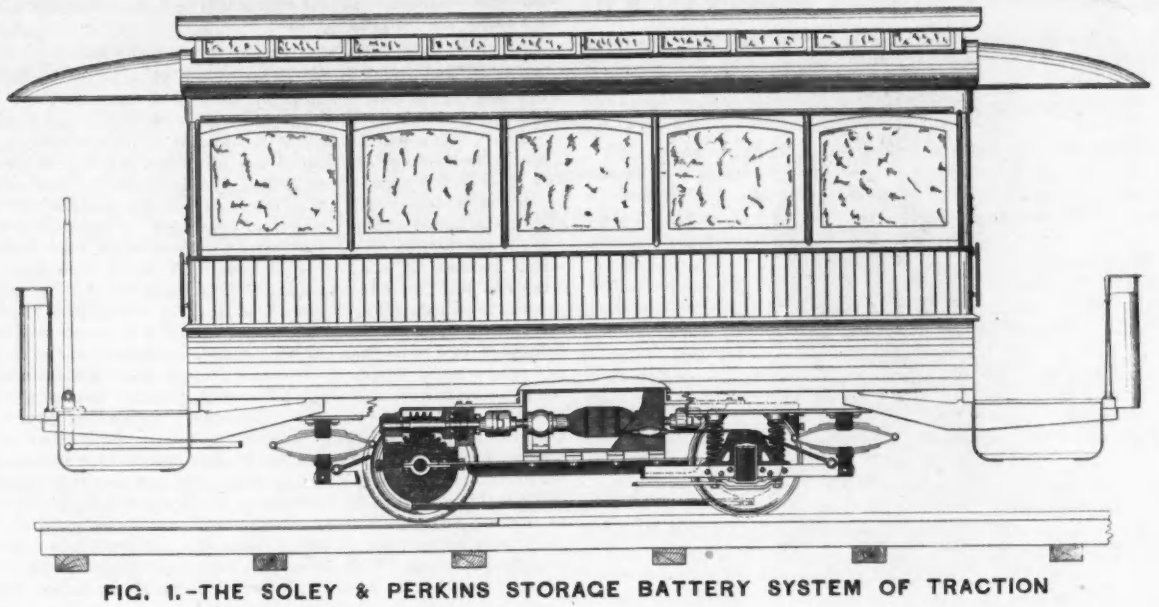
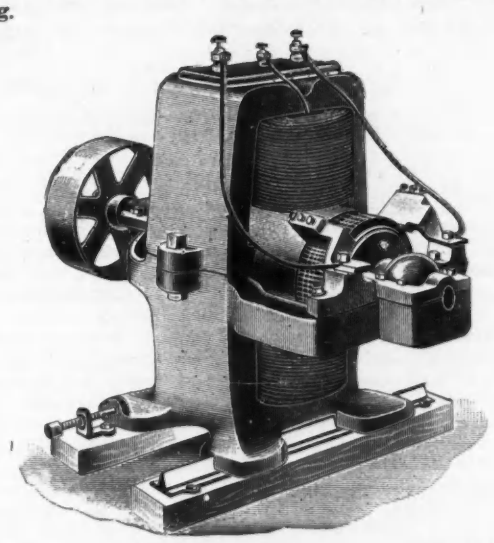


FIG. 1.—THE SOLEY & PERKINS STORAGE BATTERY SYSTEM OF TRACTION

The Elliott Electric Company's Dynamo and Motor.

The cut shown herewith illustrates the type of motors and dynamos manufactured by the Elliott Electric Company, of Cleveland, O.,

As will be seen from the cut, the machine, which is four-poled has but two field coils. The two direct poles are on a vertical line and the two consequent poles on a horizontal line. It will be noticed that all the iron on the outside of the frame is of one polarity and consequently there is no external magnetism; in other words, it is iron clad. The field coils are wound on a wooden form, and when completed the coil is thoroughly insulated with a layer of mica covered by canvas tape, making grounding from the field coil to the iron frame next to impossible. The supports for the armature are cast in one piece with the lower half of the frame, thus giving an unusually firm bearing and making it impossible for the armature bearings to get out of line. The method of lubricating used in the self-oiling boxes is unique, and is believed to be a step in advance of the present practice. Instead of employing oil rings driven by the shaft, such as are in common use, this box is provided with a spoon or flat piece of metal projecting about half an inch from the shaft, rigidly attached to it, and revolving with it. The middle of the box is provided with a single groove in which the spoon revolves. At each revolution the spoon dips into carries up with it a little oil. As the speed increases, the spoon carries enough to nearly fill the oil groove. The oil then runs each way to the ends of the box around the shaft and returns to the oil well. It will be noticed that all boxes provided with oil rings get a little warm, but the new box runs stone cold from the first revolution. The commutator has in it 91 segments, and is provided with only two brushes, set at an angle of 90 degrees on top of the commutator, where they can be conveniently examined and cleaned. The brushes consist of three pieces about an inch and a half long of 7-16 inch arc light carbon pencils, each pressed against the commutator by a very light independent spring.



THE ELLIOTT ELECTRIC COMPANY'S DYNAMO AND MOTOR.

Great care has been expended and every precaution has been taken to make the armature winding absolutely safe. The bobbins are wound in a lathe on a form. A U-shaped mica trough is placed in the bottom of the form and the wires are laid in this. When the proper number of wires are wound on, all the spaces between the wires are filled with an insulating material which, when set, holds the wires firmly and prevents all vibration. The bobbins are then laid on the armature and the coils pressed into place over the brass end plates of the core.

The nominal or rated capacity of the machines is much below their actual capacity; thus a 5 h. p. motor was run for five hours consecutively at 8 h. p., measured by a Prony brake, and for a short time ran up to 10 h. p., and was sparkless up to that load. The total variation from full load to no load can be made without touching the brushes.

The efficiency of these machines is high, that of the smaller sizes running at load up to 80 or 90 per cent. commercial efficiency.

The Soley & Perkins Storage Battery System of Traction.

Despite the somewhat discouraging results which have attended the introduction of various storage battery systems during the past few years, inventors have not ceased to work in this line, and there are now before the public several systems which claim and are worthy of attention. Perhaps the latest claimants to the invention of a practicable system of storage battery traction are Messrs. Soley & Perkins, of Frankford, Philadelphia, Pa. A good idea of the details of construction and the method of operation of this system may be obtained in the accompanying illustrations.

It has been the aim of the inventors to take everything out of the hands of the motorman, except one simple switch for starting or stopping the motor, so that however careless he may be no disastrous effects can result. The motorman has perfect control of the car by means of two levers, one of which governs the speed, and the other manipulates an exceedingly powerful brake. The car is equipped with one 20 h. p. motor, which runs constantly, but which can be shut off when descending a grade. When ascending a hill the motorman has at command two trains of gearing, one giving a speed of from zero to four miles per hour, and the other from zero to twelve miles; both, however, retaining the feature of single reduction. It has been estimated by prominent authorities that it requires about 9.6 h. p. to move an ordinary 16-foot car fully loaded and weighing 8,000 pounds up a 6 per cent. grade at the rate of four miles per hour. This means 35.8 amperes. Allowing 60 per cent. loss, it would take 57.2 amperes for the batteries to furnish. This is well within the limits of the secondary cell. The difficulties with previous storage battery systems has been, Messrs. Soley & Perkins claim, that in ascending heavy grades a discharge of 175 to 200 amperes has been required, which is an unreasonably heavy discharge and can only result in the heating, buckling and destroying of the plates and active material of the cell. This invention, however, is claimed to obviate all these difficulties, and to present a good solution of this difficult question.

The invention of Messrs. Soley & Perkins has been placed in the hands of several capitalists in Frankford, Philadelphia, Mr. James Wolstencroft, of Wolstencroft & Co., being president of the company, and Mr. William O'Neill, treasurer. A full sized model has been built, and active steps are being taken to push matters ahead as rapidly as possible.

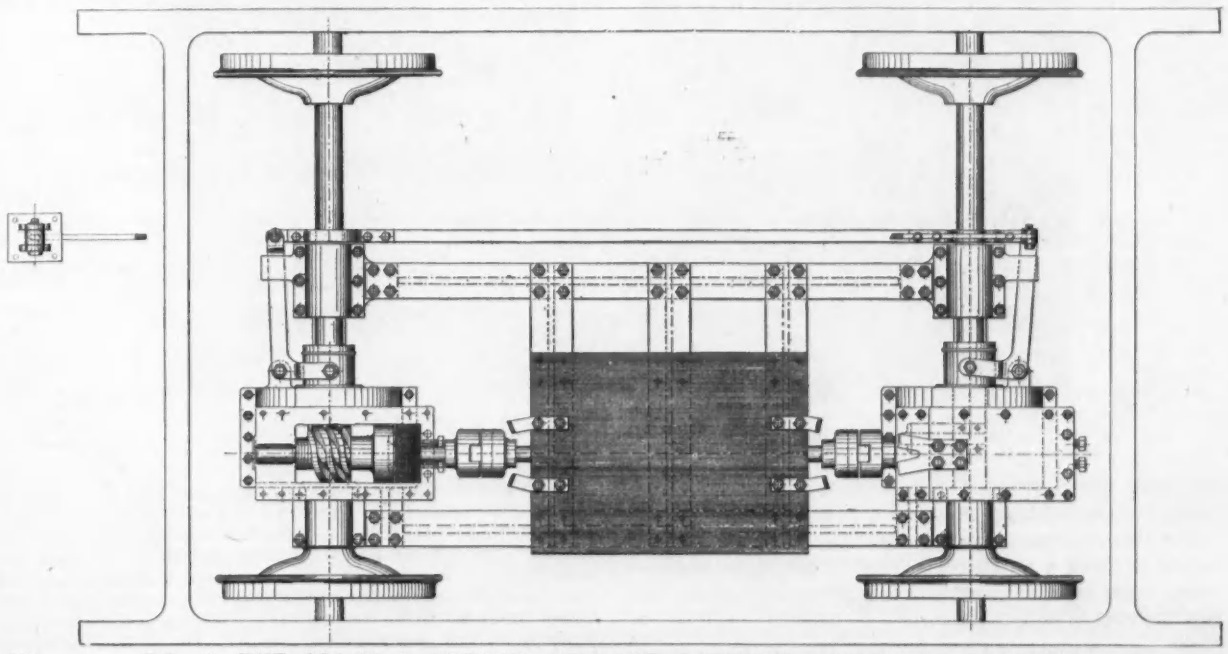


FIG. 2.—THE SOLEY & PERKINS STORAGE BATTERY SYSTEM OF TRACTION.

Panel Distribution Board.

An improved method for controlling the distribution of the electrical current in buildings, which could take the place of a number of cumbersome porcelain cutouts, has long been the desire of construction and wiring men. For the past six years they have continued, perforce, the use of the three system and the porcelain cutouts. It has remained for the talent at the command of the General Electric Company to invent a system, which not only does away with the unprepossessing, ponderous, porcelain link or plug cutouts when used as distribution centres for a number of circuits, but substitutes what is really a handsome device. This has been patented and is now placed upon the market.

The cut shows one of these panel distribution boards arranged for the distribution of current for 120 lights from a three-wire main service over twelve circuits on a two-wire system. The panel itself is a polished white marble slab ten by twenty inches. The main wires are brought to the lugs, and are continued along the front of the panel in the shape of flat hard drawn copper rods. Upon these are mounted stiff spring copper slips. Each main wire and each side of each branch circuit is protected by a fuse inclosed in a porcelain box of novel design, from the sides of which project short, flat blades of copper. By means of these blades the fuse carrier is inserted in position and is there securely held by the copper clips. A perfect frictional contact is thus insured.

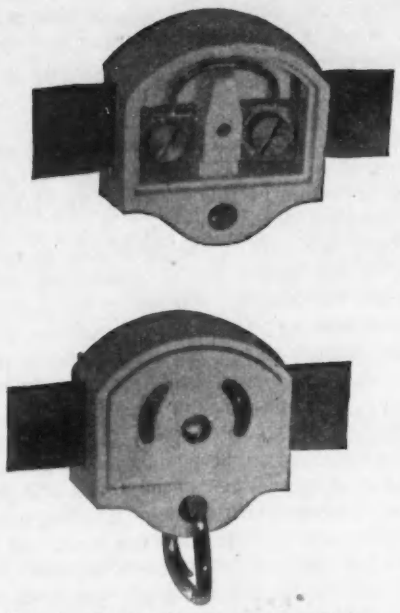


FIG. 1.—PANEL DISTRIBUTING BOARD.

The construction of the fuse carrier is peculiar. It is literally a box with three sides straight and one arched, having a partition in the centre between the two terminals to which the fuse is fastened as shown in the cut. When compared with the time honored screw plug or ordinary fuse its advantages are so obvious that practical men cannot fail to recognize and appreciate them. No short circuit can possibly occur between the terminals; the arc cannot follow the fused metal and burn them out; the molten metal cannot be blown out, the mica lined cover preventing this; the area of contact is considerably greater than in the case of the screw fusible plug, and in replacing a blown fuse the wire man is not exposed to any danger from a sudden blow of the new fuse. A fuse carrier can be removed and the fuse replaced on the spot, or a fresh one can be inserted, and that in which the fuse has blown can be carried away and the fuse replaced at the repair shop or the works. The removal of a fuse carrier, with fuse, of course disconnects the circuits. The porcelain carriers are practically indestructible by the current. They are made from the best white vitreous porcelain from the porcelain factory of the General Electric Company.

The fuse carriers protecting the main wires are furnished with a small brass ring to facilitate their removal—the smaller carriers are more easily drawn out and the ring is unnecessary.

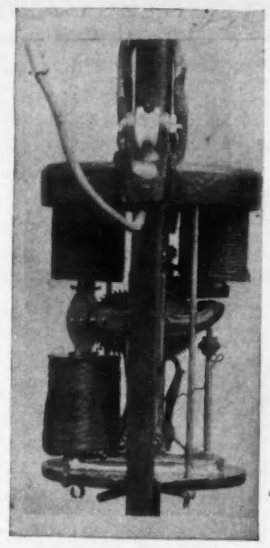
All connections are made upon the face of the panel. This disposition enables it to be fastened against a wall or to be sunk in a recess bringing its surface flush with the wall, a glass door hinged to a polished wooden frame serving to protect it from the merely inquisitive.

This style of panel distribution board can be made up in almost any combination of circuits, and can be placed almost anywhere in any building, its handsome appearance detracting in no wise from any surrounding decoration. The New Waldorf Hotel is the first building to be fully equipped with these panels, no less than 3,500 lights being distributed from a number of them.

The Mosher Arc Lamp for Incandescent Circuits.

The new Mosher clock feed arc lamp, style C 12, for use on direct current circuits is shown in the accompanying illustration and, in connection with the lamp of this company illustrated and described in The Electrical World of March 4, 1893, will excite the interest of those who believe in the future of the arc lamp as applied to incandescent circuits.

These lamps are manufactured by the Mosher Electric Company, 125-127 East Ontario street, Chicago, Ill. The lamp we illustrate is provided with a compound rheostat and cut-out. This compound rheostat is mounted on the lamp; one winding is a very low resistance, and is in circuit all the time, and the other is equal to the resistance of the arc of the lamp when burning, and is automatically cut in circuit when for any reason the arc is broken.



THE MOSHER ARC LAMP.

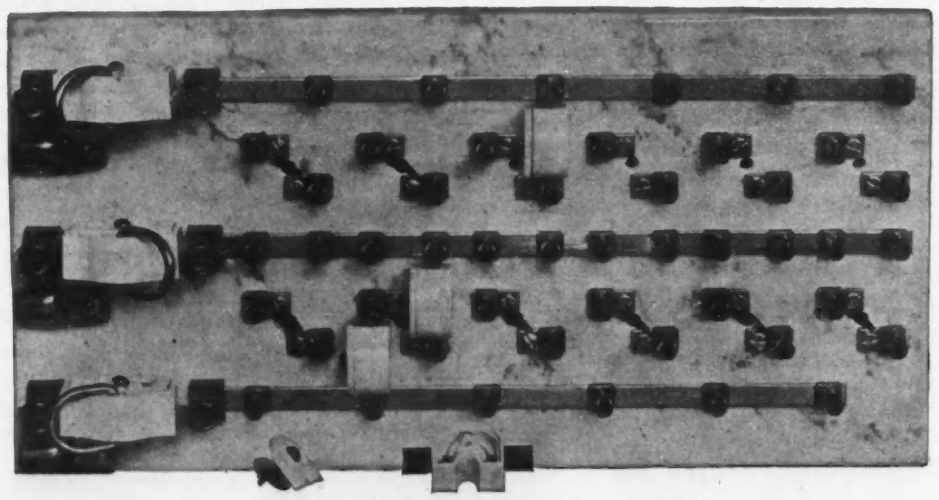


FIG. 2.—PANEL DISTRIBUTION BOARD.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

[Inquiries from our patrons for information relative to stocks and bonds of the various electric light and power companies are solicited, and will be answered in this column.]

NEW YORK, March 4, 1893.

NEW YORK GENERAL FINANCIAL STOCK MARKET.

A week of low values, doubt and disgust closed to-day with a decidedly better feeling, based upon a very general belief that the Administration which has just resumed control will inaugurate a business and financial policy that will go a long way toward clearing the foggy atmosphere of Wall street. It has been stated in a semi-official way that Mr. Cleveland has outlined a plan of action calculated to restore confidence at home and abroad. This morning the following was published by the Dow, Jones Company: We are informed upon excellent authority that the incoming Executive is in treaty with a foreign firm of world-wide influence through their correspondents here for an issue of bonds abroad. We are satisfied of the correctness of this statement. We are also in a position to announce that an offer has been made to the Treasury by an institution here for five million four per cent. bonds, the price being fixed to net the buyer three per cent. and the bonds to be paid for in gold. From this it will be seen that the policy of the incoming administration has been shaped, and that some form of tangible relief is promised. There were too many adverse conditions in the street to warrant a material advance in discount of any Administrative action, and as a consequence values remained at the low level. Among those which might be mentioned are a heavy export of gold this week, the prospects of $5,000,000 shipments next week; the very vague and uncertain condition of properties whose securities had a big slump in the depression, notably Reading and Lehigh Valley; the presence of large loans, which are liable to be called at any time by the bears; the high rate for money which ruled on call; the continued severity of the weather in the West, and belief that the bank statement would be most unfavorable. Upon the opening this morning almost all the stock sold off. Later in the day, when the bank statement was issued, making a much better exhibit than was expected, a general rally took place, carrying values to a point above the opening. It showed a net decrease in deposits of $10,703,800, and a decrease in surplus reserve of $2,881,650. There is a feeling that money will be tighter the coming week, owing to natural conditions. There is a strong demand on New York from all commercial centres throughout the Northwest and the East. Business has been interfered with by storms and the monetary uncertainty. The volume of trade is large, prices of corn, hog products, sugar and leather are higher; cotton and wheat lower. There are prospects of an increased cotton acreage this spring. Collections throughout the South and West are slow. Receipts at Chicago of produce show a large increase over those of last year. The dry-goods trade is better. There is a good demand for iron and lumber throughout the country. The cotton goods trade is excellent. Business failures for the week in the United States and Canada were 251, against 240 for the corresponding week last year. The month's bank clearings amount to $5,044,742,000. There is a feeling even among conservative houses that the low prices which have ruled for ten days are at bottom, and that the market will respond with a general advance as soon as conditions warrant. All talk of a panic, such as was met with two weeks ago, has disappeared.

NEW YORK ELECTRICAL STOCK MARKET.

As was prophesied by us last week, this list of specialties, while holding its own remarkably well, was comparatively neglected, with the exception of, perhaps, Western Union and General Electric. The stocks are not of a speculative nature, and, consequently, in times of depression are not favorites with the bears. The steadiness which they exhibited as compared with the balance of the list is most gratifying to interests which are endeavoring to encourage investments in electrical securities. None but the most active was traded in to any extent. There were less than the usual number of bond transactions, and quite a number of inquiries for the better grade of telegraph stock. Although not active is this market American District Telegraph received one sale at 55, which is a loss of about a point in a week. American Telegraph and Cable was also very quiet, at slightly lower values, the range being 88¼ to 89. Interior Conduit and Insulation Company received one sale at 63, a loss of 1¾ points. Transactions in North American were recorded each day between the range of 9 and 9⅝. This company's annual meeting is only about two months hence. From all we can learn the present low price of the stock is not fictitious, and there does not seem to be any desire on the part of the insiders to acquire holdings From these two facts it is safe to assume that the company's annual statement will not be materially better than it was a year ago, although it is believed that the prospects of the company have improved in the last ten months, and that its future will be much better than at present.

Western Union.—The strength of Western Union in the recent decline has been accompanied by a rumor that the company was likely to increase the rate of dividend to 6 per cent. It is quite likely that Western Union may be able to pay 6 per cent. at some time in the future, but it cannot be done at the present without adopting some new method of providing for the cost of construction. If Western Union saw fit to issue bonds or stock to pay for its annual betterments, it could, with the present volume of earnings, just about pay 6 per cent. on its increased capital. But for the last six years the outlay of the company for construction has ranged between $1,100,000 and $1,900,000 per annum, this sum being appropriated from surplus revenues. Last year Western Union earned 7.5 per cent. on the stock, but after deducting $1,287,158 there was left a sum equal to 5.9 per cent. on the stock. The preceding year the earnings were respectively 6.6 per cent. and 4.9 per cent., and in the year before that 7.4 per cent. and 5.2 per cent. Had the capital of Western Union been $100,000,000 last year the company could have paid after its construction outlay 5 per cent. on the stock with $180,866 over. The net revenues thus far this year have been very nearly the same as last, indicating that the company will be able to pay 5 per cent. on the present capital and allow $1,225,000 for construction, but it cannot pay more than 5 per cent. without either reducing its betterment outlay or obtaining money for that purpose from some source other than earnings. A statement showing results for a series of years follows:

	Net revenue.	Fixed charges.	Surplus.	Per cent. on stock.
1883	$7,660,349	$466,911	$7,193,437	8.9
1884	6,610,435	512,341	6,098,094	7.6
1885	5,700,921	535,063	5,165,861	6.4
1886	3,919,853	534,452	3,835,403	4.2
1887	4,037,281	533,065	3,504,216	4.2
1888	5,070,571	530,258	4,540,313	5.2
1889	6,218,041	795,668	5,422,373	6.3
1890	7,312,725	915,135	6,397,590	7.4
1891	6,605,504	931,219	5,674,365	6.6
1892	7,398,547	930,523	6,468,042	7.5

	Surplus above charges.	Outlay for betterments.	Leaving for dividends.	Per cent.
1887	$3,504,216	$1,225,915	$2,278,301	2.8
1888	4,540,313	1,219,590	3,320,723	3.8
1889	5,422,373	1,141,010	4,281,363	4.9
1890	6,397,590	1,917,182	4,480,408	5.2
1891	5,674,365	1,435,048	4,239,317	4.9
1892	6,468,024	1,287,158	5,180,866	5.9

At the first of the week a drive carried the stock down to 94¾. The closing to day showed a little weakness as compared with the quotations on Thursday and Friday, being at 95 to 95⅛. There can be no doubt of the fact that the stock, which had a decidedly speculative backing during Mr. Gould's life, has now settled into a conservative investment security. This statement is borne out by its course during the present depression. Other industrial stocks dropped all the way from 5 to 22 points. Western Union has fluctuated to a range of from 5 to 8 points.

General Electric.—The tendency was toward a decline throughout the week, with spasmodic rallies, showing that the support was strong. On Monday a decided bear raid was made, carrying the price down to 103¾. On Wednesday it regained its opening quotation of 107, closing to-day at 105 to 105⅛. Bears on the property say that the stock is declining because strong people see that the company's policy of crushing out opposition is leading to complications which must eventually do the property more harm than good, because of the animosities and hostile legislation which it is arousing. Besides, the company is incurring a heavy expense in following out its course in this respect. It is making valid also the charge that the company is seeking to monopolize the business at the public expense, and this the public will not stand, and will resent in some form which must lead to the ultimate reduction of the company's profits.

Edison Electric Illuminating.—This security was very quiet, selling off materially the forepart of the week, and closing strong at 126. Leading houses inform us that they regard it as one of the best investment properties on the list. Its capital represents actual investments which insure it a revenue for practically all time. Each month which is added to its history serves to fortify it against competition, while the gradual and gratifying development of its business gives an increase in net revenue decidedly greater than its expenses.

The Copper Market.—The copper market shows a decidedly weaker tendency than at the time of our last report. The actual trading quotation for Lake copper is 12 to 12⅛ cents; the tendency declining. This is on a basis of about 11½ cents summer delivery, and is as low a price as a number of the Lake mines can receive and still continue in operation. Our information is that the manufacturers of various kinds of copper wire and sheet are progressing

with their consolidation movement and that the spring trade will be inaugurated by the launching of several copper riveted pools.

Northwest General Electric Company, of Boston, has declared a quarterly dividend of 2 per cent., payable March 15.

Books.—On March 1 books opened to the Consolidated Telegraph and Electric Subway Company and the Postal Telegraph and Cable Company.

Scranton & Carbondale Traction Company, the People's Gas Company, of Steelton, and the Schuylkill Highland Railway Company, of Conshohocken, capital $100,000, were granted charters at Harrisburg last week.

Commercial Cable Company announces that on and after March 1 the rate from New York to all telegraph stations in China except Macao, but including the islands of Formosa and Pescadore' will be $1.96 per word. The rate to Macao is unchanged.

Telephone Affairs at Chicago.—Special advices state that telephone stocks are getting very difficult of sale, even at sharp decline. The foundation patent expires in a few days. Everybody expects a host of rival small telephone companies. An expert says of the situation: "There cannot be two telephone companies in existence side by side. A subscriber wants to reach everybody that is against competition. Manufacturers are now preparing to flood the market with telephones which would sell from $5 to $:5 apiece. It will be possible to operate a system in a small way without infringing on the Bell patents, but I cannot see how it could be done in a large city with any success. The duplicate or universal switchboard by which every operator in the exchange has the full number of subscribers duplicated before every table is an essential to rapid connections. The patent on the duplicate board has several years yet to run."

Closing Quotations.—The following were the closing quotations of electric stocks on Saturday, March 4, 1893, and the range for the week in New York:

NEW YORK QUOTATIONS.

	Par.	Capital outstanding.	Lowest.	Highest.	Bid.	Ask'd.
American District Tel....	100	3,825,000	55	55	54½	55½
American Bell.....	...	.....	201	205	....	....
Erie Telephone.....	...	.....	45	47	....	....
New England Teleph'ne	...	.....	55⅞	....	....	....
American Tel. & Cable..	100	14,000,000	88½	89	88	89
Central & So. Am. Tel....	100	6,500,000	....	....	....	111
Commercial Cables.....	100	7,716,000	....	....	175	190
Gold Stock & Tel	100	5,000,000	....	....	170	185
Bonds.....	500	500,000	....	....	....	....
Franklin.....	100	1,000,000	....	....	38	42
Mexican Telegraph.....	....	2,000.000	....	....	180	200
Metropolitan Tel. & Telegraph Co.....	....	.....	....	....	104	....
Northwestern Telegraph.		2.500,000	....	....	102	105
Northwestern Tel. 7's....	....	.....	....	....	108½	....
Postal Tel. & Cable.....	...	10,000,000	...	....	80	83
Southern & Atlantic Tel..	25	948,775	....	....	78	80
Western Union Tel.....	100	94,820,000	94¾	96¾	....	....
Real estate bonds....	1,000	1,219,000	....	....	....	....
Debenture 7's, 1875-1900.	1,000	1,920,000	....	....	112	....
Collateral Trust 5's....	1,000	8,181,000	103½	104	103¾	....
North American.....	100	39,767,200	9	9⅝	9⅝	9¾
Brush Ill. Co., common....	50	1,000,000	....	....	25	30
Edison El. Il. of N. Y.....	100	6,100,000	122	126	124	126
" " Ists.	...	.....	120	122	120	122
" " Deb's....	...	.....	....	....	....	....
Edison El. Lt. Europe....	1,000	2,000,000	....	....	2	6
" Bonds.....	...	30,000	....	....	80	85
Edison Ore Milling Co....	...	2,000,000	....	....	12	17
East River El. Light.....	100	1,000,000	....	....	....	65
Fort Wayne Electric.....	...	.....	....	....	12½	12¾
General Electric.....	1,000	30,395,600	103¾	107	....	....
Debenture 5's	...	10,000,000	98	98½	....	....
Automatic Exhibition Co. ...		2,500,000	....	....	3	5
Interior Conduit & Ins. Co.	100	1,250,000	63	63	....	....
Mt. Morris Electric.....	...	500,000	....	....	....	65
N. E. Phonograph.....	..	2,000,000	....	....	2	4
N. Y. Phonograph	...	2,000,000	....	....	2	5
N. American Phonograph ..		2,000,000	....	....	4½	6

CHICAGO QUOTATIONS.

Following are the quotations of telephone and electric stocks furnished THE ELECTRICAL WORLD by C. V. Banta, Jr., 167 Dearborn street:

Telephone Stocks:	Bid.	Ask'd.	Electrical Stocks:	Bid.	Ask'd.
Chicago.....	190	195	Chicago Arc Light and Power Co.....	116	....
Central Union	45	50	Chicago Edison Co ..	225	....
Michigan.....	....	93			

NEW INCORPORATIONS.

The New York Traction Company, New York, capital stock $5,500, has been formed to equip railroads and to supply motive power, etc. The incorporators are Jno. A. McCall, Frank K. Hain, New York City, and Chas. A. Johnson, Brooklyn, N. Y.

The Northumberland, Bloomsburg & Scranton Railway Company, of Northumberland, Pa., capital stock $500,000, has been formed to construct and operate an electric railway. Those interested are D. F. Sweeney, G. A. Wilkinson and A. T. McAllister.

The Shamokin & Elysburg Electric Railway Company, of Shamokin, Pa., capital stock $100,000, has been formed to construct and operate an electric railway in Northumberland County. The incorporators are E. C. Hamilton, C. M. Clement and J. I. Higbee.

The Lewisburgh and Mifflinburgh Electric Railway Company, Lewisburgh, Pa., capital stock $100,000, has been formed to construct and operate an electric railway in Union County, Pa. J. J. Patterson, B. K. Focht and E. W. Tool are the incorporators.

The Peninsular Light, Power and Heat Company, Grand Rapids, Mich., capital stock $20,000, has been formed to generate and supply electricity. Fred. M. Champlain, A. Bevier, J. W. Champlin and B. S. Hanchett, Jr., all of Grand Rapids, are the promoters.

The Edison Building Company, of Minneapolis, Minn. capital stock $130,000, has been formed to produce and sell electric light and power, etc. S. G. Cook, C. H. Maxey, J. S. Porteaus, J. M. Totten and J. P. Holdridge, all of Minneapolis, Minn., are the promoters.

The Citizens' Electric Light, Heat and Power Company, of Lancaster, Pa., capital stock $100,000, has been formed to supply light, heat and power by electricity to the public in that town. J. L. Steinmetz, Chas. H. Locker and Gustav Groezinger are interested.

The Pottstown, Boyertown & Reading Railway Company, of Pottstown, Pa., capital stock $150,000, has been formed to operate an electric railway. The promoters are James B. Craighead, J. M. Zook, Philadelphia, and Mahlon G. Taylor, Pottstown, Pa.

The Beers Electrical Fan and Motor Company, of Newark, N. J., capital stock $100,000, has been formed to manufacture electrical fans and motors. The incorporators are E. Hayes, A. L. Brandly, New York City; F. H. Beers and Wm. P. Beers, Newark, N. J.

The Allen-Maxwell Manufacturing Company, of Chicago, Ill., capital stock $300,000, has been formed to manufacture and sell chilled gear wheels, electric supplies and general foundry business. Victor Elting, Wm. J. Sheehan and Frank H. Knapp are interested.

The Holmesburg & Bristol Passenger Railway Company, of Philadelphia, Pa., capital stock $60,000 has been formed to construct and operate an electric railway. H. V. Massey, F. G. Edwards and Wm. V. Massey, all of Torresdale, Pa., are the incorporators.

The Sewickley Valley Passenger Railway Company, of Sewickley, Pa., capital stock $100,000, has been formed to erect an electric railway in Allegheny County. F. J. Tener, Osborne R. J. Cunningham, Sewickley, and W. B. Rommel, Pittsburgh, Pa., are the promoters.

The Fairview & Riverton Passenger Railway Company, of West Fairview, Pa., capital stock $25,000, has been incorporated to erect an electric railway. H. B. McCormick, Harrisburg; Frank Martin and Lemuel R. Spong, West Fairview, Pa., are the promoters.

The Power City Illuminating Company, Niagara Falls, N. Y., capital stock $5,000, has been formed to manufacture and use electricity for light, heat and power. H. L. Brewster, H. C. Brewster, Rochester, and Peter A. Porter, of Niagara Falls, N. Y., are the interested parties.

The Forty-ninth Street & Westminster Avenue Passenger Railway Company, of Philadelphia, Pa., capital stock $25[illegible],000, has been formed to construct and operate an electric railway in Philadelphia, Pa. J. L. Fry, George Hall and G. F. Gibson, Jr., are the promoters.

The proposed Chicago & Southwestern Electric Railway Company, of Chicago, Ill., capital stock $100,000, has been incorporated to erect an electric railway. Geo. W. Ware. F. S. Collier, O. L. Baskin, M. D. Hyers and H. R. Baldwin, all of Chicago, are the organizers.

The Middletown Electric Power and Railway Company, Middletown, O., capital stock $100,000, has been organized to operate electric street railways and to furnish power, etc. J. M. Iseminger, W. O. Barnitz, Chas. Goldman, G. C. Jacoby and W. P. Noble are the promoters.

The New England Street Railway Company, of Jersey City, N. J., capital stock $5,000,000, has been formed to build, maintain and control an electric, steam, or horse railway. A. B. Turner, Newton, Mass.; A. C. Pond, Boston, Mass., and J. B. Dill, East Orange, N. J., are the promoters.

The Canadian Whitney-Hoyt Electric Company, Portland, Me., capital stock $350,000, has been formed to manufacture and deal in all kinds of electrical machinery. Fred T. Dunlap David A. Taggart, Edwin R. Whitney and J. F. Chase, Manchester, N. H., are the promoters.

The Puget Sound Investment and Improvement Company, of Seattle, Wash., capital stock $250,000, has been formed to deal in bonds, notes, stocks, etc., to erect electric plants and operate same, etc. E. A. Strout S. E. Smith and Edwin Hughes, of Seattle, Wash., are the organizers.

The Salt Lake & Ogden Gas and Electric Light Company, of Jersey City, N. J., capital stock $1,500,000, has been formed to manufacture and supply light, heat and power, by electricity or otherwise. C. H Ludington, Jr., E. C. Henderson, New York City, and W. Talcott, Paterson, N. J., are the promoters.

The Crosstown Street Railway Company, Columbus, O., capital stock $2,000,000, has been formed to construct and operate street railroads in that city, to be operated by electric, steam, horse or other power. The parties interested are Cotton H. Allen, Wm. F. Burdell, Wm. D. Park, Fred W. Prentiss and Nelson A. Sims.

The Rochester Fire Alarm and Signal Company, of Rochester, N. Y., capital stock $30,000, has been formed to manufacture and sell fire alarm systems, electric signaling, etc. W. H. Sanger, Powers Hotel; G A. Benton, 61 German Insurance Building, and C. G. Hicks, 15 Hill Building, all of Rochester, N. Y., are the incorporators.

The Altoona Electrical Engineering and Supply Company, of Camden, N. J., capital stock $15,000, has been formed to carry on a general contract and construction business in connection with electric light, power and railway plants, etc. The promoters are W. F. Taylor, A. B. Norton, W. H. Markland, E. B. Greene, Altoona, Pa., and W. Antrim, Camden, N. J.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-176 TIMES BUILDING, NEW YORK, March 6, 1893.

The Lamp Socket Manufacturing Company has removed from its quarters in the Electrical Exchange Building to the Taylor Building, 39 and 41 Cortlandt street, Room 1[illegible]7, New York City.

Mr. Avery P. Eckert, salesman for the kerite wires and cables was summoned by wire from Fort Worth, Tex. to attend the funeral of his mother, who died at East Orange, N. J., and was buried in Woodlawn Cemetery, N. Y.

The fourth lecture in the course which the Evening Trades School, 225-227 East Ninth street, New York, is giving under the auspices of the Franklin Electrical Society, will be delivered on March 11, by Mr. Ernest V. Lallier, the subject being "Development of the Electric Arc Lamp."

The Third Avenue Railroad Company has petitioned the Board of Aldermen for permission to construct an extension nine miles in length on various streets in the northern portion of the city. The Union, or "Huckleberry," Railroad Company has accepted the privileges for extension granted to it last month.

Electric Light Wire Stolen.—Since Feb. 17, 5,800 feet belonging to the United Electric Light and Power Company has been stolen from poles in the elevated railroad structure. The thefts have been mostly in Church street between Chambers and Cortlandt streets, and in Cedar and Washington streets. It is thought that the wire was stolen by unemployed linemen.

The New York Insulated Wire Company, owing to the large demand for its wires, tapes, and vulca wire ducts on the Pacific Coast, will open a branch office at 102 Sacramento street, San Francisco, where it will carry in stock a full line of its well known goods. The office will be in charge of Mr. John R. Cole, who has been connected with the New York office of the company for several years.

Consolidated Subway Company.—The annual meeting of the Consolidated Telegraph and Electrical Subway Company, held at the office of the company, No. 18 Cortlandt street, resulted in the election of the following board of directors: Wm H. Woolverton, Charles F. Cutter, R. M. Galloway, F. Lovejoy, Edward Lauterbach, Edward J. Hall, John Jamison, Edgar L. Ridgeway and E. E. Gedney. Inspectors of election: Messrs. John H. Catrill, Joseph Kavanagh and William T. Bouchette.

The Mica Insulator Company reports a constantly increasing demand for micanite, from both home and foreign manufacturers. The special advantages which this material possesses as an insulator are that, while as proved by tests its insulating qualities are equal to those of crude mica, it can be furnished in any shape and size, ready to be put in place in a machine. The agents of this company, Eugene Munsell & Co., 218 Water street, have on exhibition a full line of samples and specialties in every form.

The Crocker-Wheeler Electric Company, New York City, has bought the large plant of the Spiral Weld Tube Company, at Newark, and is preparing to move in. A feature of the new factory will be the absence of belting and shafting throughout the entire works. The plan to be adopted is to transmit the power to a motor on each machine and drive it direct. This method will be followed in the case of every machine where it is found possible, and will result in a considerable saving of power which would be otherwise required to constantly run lines of shafting and countershafts to each machine, as well as a large saving in the cost and maintenance of belts, countershafts, pulleys, oiling, etc. It is expected that the new establishment will give employment to 1,000 hands, many of whom will go to Newark with the company.

A Novel Entertainment.—The Long Distance Telephone Company entertained a number of its numerous friends at its very comfortable quarters at 18 Cortlandt street in a novel and interesting manner. Miss Wetzler, the pianist of the Boston Symphony Orchestra, was desirous of securing an engagement with Mr Theodore Thomas, of Chicago, during the coming season, but found it quite impossible to spare the time for a trip to Chicago, while it was equally inconvenient for Mr. Thomas to come to New York. It was accordingly arranged that Miss Wetzler, playing in New York, should submit her work to the critical ear of Mr. Thomas at the Chicago end of the long distance telephone. The Long Distance Telephone Company with its usual courtesy decided to enlarge the programme by inviting several other artists to perform for the benefit of its friends. The audience were treated to some very excelent numbers by Miss Wetzler, and several songs by Mr. Plunket Greene, the new baritone who has scored such a success since his recent appearance in this country. Mr. Thomas expressed himself as much pleased with the performance. The New York listeners were also favored by several selections from the Chicago end of the line. A little later a light lunch was served. Mr. P. A. Picknerell managed the affair in his usual happy manner, and every one expressed themselves as delighted with this unusual form of entertainment.

Mr. John W. Mackay, of the Postal Telegraph and Cable Company and the Commercial (Mackay-Bennett) Cable Company, who was wounded two weeks ago in an attempt on his life in the street of San Francisco, has offered two special prizes of gold medals valued at $150 and $100 respectively for the best typewriter receivers. The conditions are that messages are to be handled for 45 minutes and the awards made to the operators turning out the greatest number of messages in the best shape. The Committee of Arrangements of the tournament, which is to be held in New York at Hardman Hall, March 11, has promptly complied with the conditions prescribed by Mr. Mackay through Superintendent Storror. This involves a complete change in the second event or message class. As originally scheduled, this provided for a test of 10 messages. Now the second event will be a message class of 45 minutes' duration, the sending operator to be selected by the committee. The entrance fee will be the same as in the others—$3. In order to give outside operators every possible opportunity to send in their names for places, the committee announces that the closing of entries will be postponed until March 8. The entries already number 40. Competition may be private or public. The object of the proposed tournament is to create a fund for the maintenance of the Telegraphers' Mutual Relief Association, one of the objects of which is to endow one or more hospital beds.

PITTSBURGH NOTES.

PITTSBURGH, March 4, 1893.

The Lindell Street Railway Company, of St. Louis, Mo., the largest street railway company in that city, has awarded to the Westinghouse Electric and Manufacturing Company the contract to equip its plant with motors and generators. This contract is of special importance, because the company has for several years operated its lines with other street railway systems. The first order is for the equipment of 100 cars and for 2,000 h. p. of electric generating apparatus.

The Philadelphia Traction Company decided about a year ago to adopt the Westinghouse electric street railway system. It has now equipped the Katherine and Bainbridge street lines, where it has made a thorough test of the Westinghouse apparatus. The Traction company has recently given the Westinghouse company an order for about 600 electric railway motors and eight 500-h. p. direct connected generators and engines. It also contracted with the Westinghouse company for all electrical apparatus to be used on the Philadelphia street railways and suburbs. This is the largest contract, perhaps, that has ever been given to any electric company for street railway apparatus.

Incandescent Lamp Situation.—In the case of the Edison company against the Westinghouse Electric and Manufacturing Company under proceedings instituted by the latter company for the purpose of determining the rights to manufacture the "stopper lamp," Judge Acheson read an opinion in the U. S. District Court of this city to the effect that the question was one not to be determined on a motion for a preliminary injunction on *ex parte* affidavits at the request of the defendants, but that the difference in the construction of the lamp is such that a decision should only follow a final hearing after the taking of testimony in the usual manner and after trial. It was also decided that the question might be properly determined in this court under pending proceedings. There is yet pending the petition of the Westinghouse Electric and Manufacturing Company asking the court to restrain the Edison company from bringing suit against customers of the Westinghouse company. When the arguments in this case will be heard has not yet been determined.

The popularity which has been attained by local electric street railways is very strikingly demonstrated by the following statement from the Pittsburgh & Birmingham Traction Company. The statement shows the comparative operations of the road during 1891 and 1892.

Passengers carried	1891	5,483,882
" "	1892	6,475,082
Increase		991,200
Gross earnings	1891	$284,583 79
" "	1892	346,821.65
Increase		$62,237.86
Net earnings	1891	$123,973.60
" "	1892	184,268.06
Increase		$60,295.06
Operating expenses	1891	$152,490.28
" "	1892	162,553.59
Increase		$10,054.31

The Allegheny County Light Company held the twelfth annual meeting of its stockholders in the Westinghouse Building last week. Although not a large number of the stockholders were present, of the 5,000 shares of capital stock 4,500 were represented in holders and by proxy. The report of the treasurer, R. D. McGunningle, for 1892 was received. The total assets Dec. 31, 1892, were shown to be $1,576,315.19, balanced by the liabilities, which are as follows: Capital stock issued, $565,000; bonds, six per cent., 20 years, $500,000; accounts payable, $55,327.62; bills payable, $232,515.39; accrued interest on bond and mortgages, $12,500; deposit account, $564.15; undivided profits, $209,608.03. The gross earnings for the year were: From sales of light, $366,762.93, minus operating expenses, $245,013.07, leaving earnings over and above operating expenses, $121,748.96. This last, after deducting the interest on bonds and mortgages, interests and discounts, leaves $75,637.09 as the net earnings. The number of incandescent lamps in operation last December was 41,000, against 36,000 of December, 1891. The company operates 1,132 arc lights. The following directors were elected to serve the ensuing year: George Westinghouse, Jr., H. H. Westinghouse, Robt. Pitcairn, Jas. H. Willock, John E. Ridall, C. L. Magee, Wm. Eberhardt, G. H. Blaxter and Wm. McConway.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 91, Hathaway Building, 620 Atlantic Ave.,
Boston, Mass., March 4, 1893.

The American Magnetic Electric Company, Boston, will soon bring out many new and attractive goods of its especial manufacture.

The Hart switches, manufactured by the Hart & Hageman Manufacturing Company, of Hartford, Conn., were shown at the St. Louis Convention by Mr. Geo. S. Searing, of Chicago, and were much admired.

A handsome circular price-list, very tastefully gotten up, has been received from the Cutter Electrical and Manufacturing Company, of Philadelphia.

At a recent meeting of the directors of the Electric Gas Lighting Company, Mr. Louis W. Burnham was re-elected vice-president and general manager and Wm. W. Burnham treasurer.

Mr. W. C. Bryant, of the Bryant Electric Company, of Bridgeport, Conn., had on exhibition at St. Louis during the recent Convention a handsome switchboard with samples of his various switches and other specialties, which attracted much attention.

The Boston Electric Company, Boston, has secured the New England agency for the Carpenter Electric Heating Company and is showing a full line of these goods. It is astonishing to note the short space of time that it requires after the current has been turned on before the desired heat is reached.

Messrs. M. E. Baird and A. D. Newton, of the Eddy Electric Manufacturing Company, of Windsor, Conn., exhibited at the St. Louis Convention the new Eddy motor, which every one who saw it pronounced a beauty.

The Automatic Railway Track Sander Company, a corporation formed for the purpose of manufacturing automatic railway track sanders, has been organized at Portland, Me., and the following officers elected: President, C. V. Holman, Boston; treasurer, F H. Verrill; clerk, E. C. Verrill; directors, C. V. Holman, E. C. Verrill and J. B. Moran, Boston.

A stock company is being organized in Philadelphia to manufacture an electrical music leaf turner recently patented by W. J. Dailey, lately of Lynn, Mass. All of the large piano manufacturers are interested in the company. The invention is intended to do away with the necessity of turning the leaf by hand, and by a simple pressing of the key the sheet of music is turned over.

Mr. Dumorlin, electrician of the West End Railway Company, of Boston, has been making numerous tests of the O'Neill electro-thermal system of electric car heating, and it has proved a great success. He is able to raise the temperature from 44 degrees to 60 degrees in a short time while the car is running, and to keep the car at 61 degrees for nearly three hours after the current has been turned off.

The Pettingell-Andrews Company, Boston, since its appointment as New England agents for the Siemens-Halske Electric Company, of America, is pushing its trade into the street railway field with more vigor than heretofore, and as it has secured several contracts lately in this field we may expect to find it figuring more prominently in street railway interests. It also represents as sole agents the Boston Electric Wire Company and as New England agents the Okonite Company, the Interior Conduit and Insulation Company, and the Bryant Electric Company.

S. H. Howe, ex-mayor of Marlboro, Mass., and also president of the Howe Shoe Company, has recently bought a controlling interest in the Marlboro Electric Street Railway Company from E. R. Alley, executor of the estate of Samuel Boyd. All the stock, with the exception of 30 shares out of a total 500, was held by the Boyd heirs. The transfer means a very large financial gain to the corporation. The plans for the extension to Marlboro Junction are already perfected, a part of the material purchased, and work is expected to start as soon as the frost is out of the ground.

The trolley war which has raged at Beverly, Mass., for three years is ended. At a conference between the selectmen and Manager Foster of the Lynn & Boston Street Railway Company yesterday, it was agreed that the trolley system be extended to Beverly under the same conditions imposed in Salem. The company agreed to a single fare from North Beverly to Salem or Peabody, where two fares have been charged in the past. The company will commence operations as soon as the ground is open, and will lay new rails throughout. They expect to spend $100,000 in Beverly this year.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, March 4, 1893.

The Dayton Globe Iron Works Company, of Dayton, O., distributed at the St. Louis Electric Light Convention handsome illustrated catalogues of its new American turbine water wheel, which is coming into extensive use for driving electric light and power stations.

The Central Electric Company, of Chicago, is putting on the market a porcelain socket without a screw (with the exception of the necessary binding screw). All the parts are thoroughly well made. Both wires can be cleaned an equal distance from the cord knot, thus insuring the socket hanging plumb.

Mr. F. P. Little, of the F. P. Little Electrical Construction and Supply Company, of Buffalo, was one of the attendants at the St. Louis Electric Light Convention.

The Elgin Electric Club was organized on Jan. 24, 1893, at Elgin, Ill. The officers are: President, Frederick Purdy; vice-president, Dr. G. L. Marion; secretary, J. Frank North; treasurer, Henry Klinder; librarian, R. W. Pikerton. The club has a membership of 48, and applications are constantly being received. Weekly meetings are to be held, and the object of the association is the encouragement of scientific investigations and the discussion of the theory and application of electricity.

The Electric Appliance Company will shortly acquaint the trade with the merits of its latest specialty, the Eddy windlass. This windlass has several new and valuable features which easily recommend it. It is so arranged that the windlass is automatically locked by the removal of the crank, and released when the crank is replaced. The lock is such that it prevents the windlass from being tampered with in any way, and yet does not require any such accessory as a padlock and key, which are always a source of continual annoyance. The locking mechanism is so arranged that it cannot be affected by sleet and ice.

The Mackaye Spectatorium.—One of the most unique and interesting features of the Columbian Exposition in Chicago will be the enterprise known as "The Mackaye Spectatorium," which is being built at the north end of Jackson Park on the lake shore by the Columbian Celebration Company. This company is composed of the best known and most successful financiers and social leaders of Chicago, and will carry out the original ideas of Mr. Steele Mackaye, for whom the building is named. The building with its great studios and power-houses covers about nine acres of ground. It is strikingly original in design, massively grand, beautiful as to decoration and in every way fitted to harmonize with the presentment of Columbus and his discovery, which is to be given within its walls. This historic production will cost about $1,500,000. Those who have been permitted to see the models assert that Mr. Mackaye has taxed to the utmost the resources of mechanics, electricity and artistic possibility. With these surroundings the production itself would be more than noteworthy were it not for the fact that in connection with this project names never before appearing in this field of work have become conspicuous. In a dramatic way the presentation will be in keeping with its mechanical ingenuity and in a lyric way it will be in perfect accord with the grandeur of the building.

ENGLISH NOTES.

(From Our Own Correspondent.)

London, Feb. 22, 1893.

Liquid Air.—By special request of the Prince of Wales, Prof. Dewar delivered a lecture this afternoon at the Royal Institution on liquid air.

Westinghouse Separable Lamp.—Mr. Hiram S. Maxim has written to the *Engineer*, stating that ten years or more ago he patented a lamp which was exactly upon the lines of the new Westinghouse lamp. Mr. Francis Jehl, a well known Austrian engineer, also states that in 1882 a glass blower named Böhm described a lamp similar to that now known as the "Westinghouse Separable Lamp."

Electricity Supply Business in London.—The report of the Kensington & Knightsbridge Company, which supplies a district almost entirely residential, is very satisfactory. A dividend has been paid at the rate of four per cent. for the year, the company's customers have increased from 436 to 550, or by 26 per cent., and the "lampage" has increased from 34,000 to 47,000, *i. e.*, by 36 per cent. Both the St. James and Pall Mall and the Westminster companies announce important reductions in their charges, viz., from 7d. per kilowatt-lamp to 6d., plus a sliding scale arrangement bringing the price of a Board of Trade unit down to a minimum of 5d. All these companies, it may be mentioned, distribute on the three wire system.

Liverpool Overhead Railway Electric Signals.—In view of the recent frequent recommendations of the Board of Trade officials in favor of the adoption of some form of automatic electric signals on the busy portions of our railways, the working of the Timmis automatic electric signals will be watched with considerable interest. Leaving out the question of interest on capital and expenditure and depreciation, there seems reason to suppose that solely from the financial aspect the signals will be found advantageous. Each station comprises four signals and each signal requires a lowering current of five ampères and a holding down current of .25 ampère. Assuming a three-minute service and 20 hours a day, each signal will be lowered 400 times, and the current being at 40 volts pressure it is evident that about 80 watt-hours per day will be required by each, or one kilowatt approximately for the entire line. This, however, does not include the holding down current; assuming each signal to be held down 1½ minutes, it will be down 600 minutes per day, or for the entire line about 5¼ kilowatt-hours, making in all a total of 6¼ kilowatt-hours. As a kilowatt can be produced for about 3d., the cost of working these electric signals for the entire line is under 2s. per day, or less than the wages of a single signalman.

Electricity Supply Business.—Following the example of the two companies I mentioned last week, the London Electric Supply Corporation has announced a reduction in its charge for the Board of Trade unit from 7d. to 6d. with a sliding scale down to 5d. A few weeks ago the St. James and Pall Mall Company declared a 7¼ per cent. dividend, and last week the Kensington and Knightsbridge and Westminster companies declared dividends of 4 and 3 per cent. respectively, while at Newcastle, which one would consider the home of the gas industry, the two local companies have recently paid dividends of 4 and 5½ per cent. A day or two ago the Electricity Supply Corporation, the low pressure concern supplying a compact area of about one fifth of a square mile, containing a large number of theatres and restaurants, declared a 5 per cent. dividend. It is interesting to note the difference between what may be called the *capital density* per square mile for companies like the St. James and Pall Mall and the Electricity Supply Company, which cover compact and highly favorable areas, and concerns like the Kensington and Knightsbridge and Westminster, which supply districts from five to ten times as large and of a residental character. The total capital outlay per square mile of the St. James and Electricity Supply concerns averages nearly £1,000,000, while that of the Kensington and Knightsbridge and Westminster companies only averages about £200,000.

Experimental Researches on Alternate Current Transformers.—The discussion on the paper read by Dr. Fleming at the end of November on the above subject before the Institution of Electrical Engineers was terminated on Thursday evening last by a most interesting reply by the author. The time occupied in reading the paper and discussing it was, it will thus be seen, commensurate with the lengthy and weighty nature of the paper itself. The chief question which will probably be asked by electrical engineers when they have digested this contribution to current electrical engineering knowledge will be, "Stands the 'hedgehog' where it did?" The "hedgehog" was first heard of at the British Association meeting in 1889, when its parent claimed for it a much higher *all-day* efficiency than could be possibly obtained with any form of closed magnetic circuit transformer. Subsequently when the loss in the mains due to the abnormally large magnetizing current required by the "hedgehog" was urged against it, Mr. Swinburne devised a condenser to neutralize this loss. Dr. Fleming has throughout been very prominent in expressing his disbelief in the virtues of the "hedgehog" transformer; and what is more important, his paper, and especially his reply on Thursday evening last, completely justified his attitude of disbelief. With regard to the first contention of higher *all-day* efficiency, he showed by actual figures, deduced from actual tests that a 6,000-watt "hedgehog" had an all-day efficiency, on a 10 per cent. load diagram, of 74.2 per cent., that of a 6,000-watt Mordey being 74.3. But the transformer itself, as electrical engineers are beginning to find out, is not the only thing to be considered. Dr. Fleming, therefore, supposed a group of open and closed circuit 6,000-watt transformers arranged at the end of a feeder a mile long In the case of the four "hedgehog" transformers the all-day loss in the line would be 2½ units, and the all-day loss for the Mordey transformers be a little under ½ unit. Taking the *total* losses, the four "hedgehogs" would dissipate a little over 18 units, and the four Mordey transformers a little under 15 units, the secondary circuits developing in both cases 60 units. The difference between the total losses would amount in a year to 860 units, which at the cost price of 3d. per unit would amount to $10. Dr. Fleming then dealt with the condenser remedy, remarking, by the way, that he had not yet found a condenser without considerable dielectric hysteresis. Figures deduced from tests were then given for condensers placed at the dynamo end of the primary circuit, for the purpose of mitigating losses on a "hedgehog" system. These figures showed that such a group of condensers would themselves dissipate 2.4 units per 24 hours, while the line losses they had to save were 2.2 units Hence their addition to the system was merely "robbing Peter to pay Paul." They involved rather more loss than they saved. I must again repeat that these figures are not purely hypothetical, but actual figures produced from actual tests of actual apparatus. Dr. Fleming concluded his pulverization of Mr. Swinburne by suggesting the drastic remedy that Mr. Swinburne should return to the kind of "hedgehog" transformer first devised by Mr. Cromwell Varley in 1856, in which he left the ends of the core wires long enough to be folded back and joined together round the body of the transformer. Not content with having demolished Mr. Swinburne and all his fallacies, Dr. Fleming then proceeded to deal equally severe blows at his low pressure antagonists, Messrs. Crompton and Arthur Wright. The latter has had considerable experience with both high and low pressure distribution and transformer manufacture. He had stated that there was no room for an alternating current station inside an area of which the radius was 1¼ miles. Dr Fleming assumed a 10 per cent. load diagram, and an equal outlay by either system on generating plant, etc., and proceeded to compare first cost and annual maintenance of a low pressure and high pressure feeder one mile in length, and of 24 kilo-watt maximum capacity, giving 200 volts across the outer terminals of a three-wire system at the business end in the low pressure system, and 2,000 volts at the transformer terminals in the case of the high pressure system. Three drops at full load were assumed on the feeder to be 40, 30 and 20 per cent. Taking the first case, the all-day efficiency of both high and low pressure systems came out at 87 per cent. The respective capital outlays were then put forward, the figures being based upon tenders from substantial firms. These were followed by estimates for depreciation (five per cent on high pressure cables, 15 per cent. on transformers, 2½ per cent. on low pressure cables). The net outcome of Dr. Fleming's cogitations was that the annual cost of energy wasted (3d. per unit) plus interest on capital outlay and depreciation, amounted in the case of low pressure feeders to £111 10s., and in the case of high pressure feeders to £96 10s. His conclusion was that as long as they kept within the limits of practical experience they would find it to be demonstrated that the annual cost of a high pressure feeder one mile long delivering a maximum of 24 kilowatts was considerably less than for a low pressure feeder, while the capital outlay for the low pressure feeder was about double that of the high pressure feeder. Taking lower percentage voltage drops along the feeders and higher load factors, the case became considerably more favorable for high pressure distribution. Dr. Fleming, therefore, contended that his figures, which he had endeavored in every way to subject to test, did not in the least degree confirm the statements of Messrs Arthur Wright and Crompton; while on the other hand they showed most decidedly that there was no room outside a radius of one mile for low pressure distribution. The future, he said, was clearly with high pressure distribution, since they all looked forward to increased load factors, and with increased load factors the efficiency of low pressure systems tended to a limiting efficiency of 70 per cent., while that of high pressure systems tended as a limit toward 95 per cent. Dr. Fleming further contended that if he took capital outlay and generating plant into consideration his case was stronger. It was also further strengthened, he urged and endeavored to show, by a concentrated load, *i. e.*, a large output for a few hours, such as obtains in the city of London. With this Dr. Fleming terminated one of the most valuable and lengthy discussions which has ever been held at the Institution of Electrical Engineers.

News of the Week.

THE ELECTRIC LIGHT.

Clyde, O., is soon to have an electric light plant.

Huntington Valley, Pa., is discussing the electric light question.

Hempstead, Tex.—Work has commenced on the new electric light plant.

DeGraff, O., has voted to issue bonds to the amount of $12,000 to establish an electric light plant there.

The Edison Electric Light Company, of Philadelphia, has announced that it is prepared since March 1 to attach 30,000 additional lights to its mains.

Light for East Randolph, N. Y.—Woodmancy Bros., who have recently put in an electric light plant at Randolph, will extend their lines to East Randolph as soon as the weather permits.

THE ELECTRIC RAILWAY.

Albion, Mich., will probably build an electric railway this year.

The Leavenworth, Kan., dummy line is being changed into an electric system.

The Philadelphia Traction is perfecting plans to rebuild the Market street cable line as soon as the weather will permit. It is reported that the cable system is to be abandoned, and a

trolley line installed on the principal thoroughfare. An underground trolley system is under discussion.

The Kalamazoo, Mich., street railroad property, for two years in litigation for the foreclosure of a mortgage, has been formally transferred to the General Electrical Supply Company, of New York, the last of the $32,000 purchase price being paid. The report of the receiver, W. R. Adams, shows receipts from moving cars $23,613.86; from sale of receiver's certificates, $22,957.91; on hand, $517.16; operating expenses, $46 084.61.

The Spear Electric Traction Company, of Passaic, N. J., with a capital stock of $100,000, has been incorporated. The system which this company proposes to test is the invention of Alfred Spear, who claims that by it a speed of from two to three miles per minute can be obtained. The system involves an elevated structure with long narrow cars pointed at each end, with a seating capacity of 12. These vehicles are to be made of basketwork covered with light wood and not to weigh more than 1,500 pounds each. The cars will be suspended so as to ru nbelow the track.

A Network of Electric Railroads.—The owners of the Orange Mountain cable road and a number of Boston capitalists are negotiating for the purchase of the Orange Crosstown & Bloomfield Street Railway, and have an option on it until the first of next month. It is proposed to operate the line by electricity and also to extend it north through Brookdale to Paterson and also south to South Orange, and probably to Millburn and Morristown. A spur will also be built from the Washington street terminus through Watchung Heights to Montclair, and another branch is to run through Hurlbut street and other thoroughfares to East Orange. The Orange Mountain Cable Company, which has now almost completed its road up the mountain side, has plans drawn for a road leading from its base to the Highland avenue station of the Morris & Essex Railroad, whence it is proposed to extend it north to the Green in West Orange. The New Jersey Traction Company has also acquired the right of way for a line running south from its main road in West Orange to Central avenue, and thence east to East Orange, through which it is proposed to run to the power-house in Newark. The company is also to build a new power house at the base of the Orange Mountain and extend its line up the slope to Eagle Rock. These proposed lines will all be operated by electricity and will form a network of rails through the Oranges. Even more extensive improvements and prolongations are contemplated in the near future.

MISCELLANEOUS NOTES.

Mr. D. C. Spruance, of the Helios Electric Company, of Philadelphia, was among the visitors to St. Louis during the recent convention.

United States Senator-Elect Smith having resigned as Electrical Subway Commissioner, Governor Werts, of New Jersey, has nominated State Treasurer George R. Gray to the office.

Messrs. Jas. J. Murray & Co., of Philadelphia, had one of the finest exhibits at the St. Louis Light Convention, consisting of samples of their arc and incandescent globes and various kinds of shades.

The Buffalo Electrical Society.—At the last meeting of the Buffalo Electrical Society Mr. Frank Kitton read an interesting paper on "Long Distance Transmission of Power by Direct Current." At the next meeting of this society Mr. Frank C. Perkins will present a paper entitled "Will the Closed Conduit Supersede the Trolleys in Large Cities?"

The Ward arc lamp was well to the fore at the St. Louis Convention, Mr. R. B. Corey being on hand personally to represent the company.

Engineering Association of the South.—The regular February meeting of the Engineering Association of the South was held at the Association headquarters, Nashville, Tenn., on Thursday evening, Feb. 9, President E. C. Lewis, presiding. The paper of the evening was presented by Prof. Wm. T. Magruder, of Vanderbilt University, his subject being "Mechanics as a Fine Art."

The Vincennes Electric Light and Power Company, Vincennes, Ind., recently held its annual meeting and re-elected the present board of directors and H. W. Frund, general manager. Officers' reports show 100 per cent. increase in business and $20,000 worth of new apparatus installed during the past six months. This company has one of the finest equipped plants in America.

Messrs. C. P. Mackie, Robb Mackie and Herbert Laws Webb exhibited at the recent St. Louis Electric Light Convention the ingenious device manufactured by the Electric Selector and Signal Company, of 45 Broadway, New York. By means of this simple instrument an electric light superintendent can have any circuit he desires automatically cut in or cut out at any hour for which the selector is set. The device also has a large field of usefulness in telegraphic work.

The Incandescent Light and Power Company, of Norwalk, O., has made an assignment to J. W. Foster and F. H. Jones. Assets are approximated at $35,000; liabilities are unknown, but are estimated to be at least $50,000. While it has been known for some time that the affairs of the company were in bad shape the assignment was unexpected. It was reorganized a few weeks ago, with R. W. Huntington, of Cleveland, as president. The former officers were ex-Postmaster D. W. Vail, president; Dr. A. L. Osborn, treasurer, and Attorney Charles Suhr, secretary. A majority of the stock was held by Cleveland parties.

The Department of Electrical Engineering of the University of Minnesota has made rapid strides since its organization in 1891. A recent issue of the Minneapolis *Evening Tribune* contains an interesting account of the course, and the equipment of the electrical laboratory. The department is in charge of Prof. George D. Shepbardson, who is well known in the electrical field. The course of study covers a period of four years, the first two being devoted largely to mathematics and general physics, and the last two to technical work. During the senior or last year, considerable attention was given to the theory and practice of alternating currents, the designing of electrical apparatus, the practical operation of dynamos, motors, etc., a careful study of arc and incandescent lighting systems, and the various styles of lamps, the design, construction and operation of isolated plants and central stations, etc. In connection with the work at the University the students have an opportunity to inspect and report on numerous plants in Minneapolis and vicinity. The laboratory is well equipped with dynamos and motors and measuring and testing instruments, and in fact all apparatus necessary to the work.

The Telephotos.—On the evening of the 9th ult. the members of the Buffalo Electrical Society and their friends were entertained by Mr. C. V. Boughton, the inventor of the "telephotos," at his works on Seventh street. The "telephotos" is designed for the purpose of communicating between ships at sea, armies in the field and for other similar purposes, now usually accomplished by means of rockets, flags and other visual devices. The Morse telegraphic code of dots and dashes is employed for signals which are produced by means of incandescent lamps, operated by dynamo currents and controlled by a keyboard on which the characters are designated, or marked, by Roman letters, thus enabling any one, whether familiar with the Morse code or not, to transmit dispatches, which must, of course, be received and translated by an attendant expert in reading those characters. The lamps are controlled by a keyboard not dissimilar to the keyboard of the conventional typewriting machine. The case is made of aluminium, to secure lightness, and is contained within an area of two and one half feet square, with a depth of six inches. The keyboard, comprising 37 letters, numerals, etc., occupies one foot and six inches; the remaining portion is taken up by the electrical connections. Attached to the keyboard is a very ingenious and simple device, the invention of Mr. Boughton, which locks all the keys except the one depressed and prevents more than one key being depressed at a time. Mr. Boughton has also applied this device to typewriting machines. The weight of the keyboard is about 75 pounds and that of the lamp frame 120 pounds. It is stated that the weight of a wagon containing all the apparatus necessary for field operation, including boiler, engine and generator, will not exceed 1,500 pounds. Mr. Boughton has demonstrated that his signals can be read at a distance of three miles by daylight and ten miles at night. He has also just completed a keyboard which contains an automatic device for recording messages as they are transmitted. Mr. Boughton sails in a few days for England, where he will exhibit his system to the British Navy. He will also have it in operation at Washington during the international navy review to be held there in April.

Industrial and Trade Notes.

The C. & C. motor was shown in operation at the Electric Light Convention at St. Louis last week, and its smooth running and handsome appearance called forth many compliments.

Mr. A. J. Ham, Mail and Express Building, New York, reports large and increasing sales in Kerite wires and cables. Duplicate orders, such as Mr. Ham is receiving, speak volumes.

The Berlin Iron Bridge Company, of East Berlin, Conn., is at work putting up the roof trusses on the new light and power station for the Electric Light and Power Company at Syracuse, N. Y.

The Wrought Iron Bridge Company, of Canton, O., whose Eastern office is at 136 Liberty street, New York, is now ready to act as bulk contractors in the erection and equipment of power houses and car sheds.

Messrs. Washburn & Moen displayed samples of "Salamander" fireproof wire at the St. Louis Convention, and the delegates were much interested in the wonderful tests that have been made of this remarkable wire.

The Joseph Dixon Crucible Company, Jersey City, N. J., has issued a catalogue descriptive of its graphite productions, and also a little folder calling particular attention to the use of graphite for electrical work.

The Champaign (Ill.) Electric Light and Power Company has issued an unusually attractive little circular entitled "Light," which sets forth in an admirable array the advantages of the incandescent lamp over any other form of illuminant.

The General Incandescent Arc Light Company, of 59 Duane street, New York, had at the recent Electric Light Convention an extensive line of samples of the new general incandescent arc lamp in charge of Mr. A. Noll. The brilliant display attracted much attention.

The Builders' Iron Foundry, of Providence, R. I., has received the contract for 28 spring return carriages for 12-inch breech loading rifled mortars. These carriages weigh about 12 tons each, and are to be used for coast defense in connection with the rifled mortars made by this company.

The W. D. Graves Electric and Manufacturing Company, of Cleveland, O, will in the near future be in better shape to do business than ever before. All accounts will be paid as soon as presented, and matters are being straightened out as rapidly as possible. The factory is now running full force, and orders are promptly filled.

J. Jones & Son, of which company Mr. Ernest A. Lowe is manager, are the agents for the DeMott electric motors. These are miniature electric motors designed to run mechanical toys, model machinery, toy launches, railroads, music boxes, ventilating fans, etc. The largest sizes will operate dental outfits, sewing machines, or small lathes.

The Carborundum Company, of Monongahela City, Pa., has just obtained a patent, which is briefly described in the patent department of this issue, on carborundum. As electricity performs a very important part in the manufacture of this material it possesses particular interest for electricians and others in various ways connected with this line of work.

The Lemaire Decorative and Electrical Manufacturing Company write: "The business of Mr. Paul Lemaire for the manufacture of arc lamps, decorative bronzes, electric fixtures and electrical construction work having been taken by the above named company, the offices will be removed after March 1 to the factory, 258 and 260 Eleventh avenue, New York.

The Southern Electrical Supply Company, of St. Louis reports very brisk sales of Interior Conduit and Okonite wire in its territory. The following buildings are the latest to be equipped with the Interior Conduit system throughout: Rialto Building, Mercantile Club, St. Nicholas Hotel, Security Building, Planters Hotel, Union Trust Building and Polytechnic School Building.

The J. T. Case Engine Company, of New Britain, Conn., has gotten up an attractive little folder describing the various kinds of gas engines manufactured by it, including the pedestal, bracket and hanger engines. Simplicity, compactness, lightness of moving parts, direct action, automatic lubrication and perfect regulation are some of the points claimed in favor of these engines.

The Crandall Manufacturing Company, manufacturer of electrical specialties, of Philadelphia, has removed from 12 South Fourth street to 66 North Fourth street, where it occupies the entire ground floor and basement, 20 feet by 70 feet. It is the intention of this company to remain permanently at this address and fit up its offices in the most modern style. Mr. Crandall reports business very brisk.

The McGuire Manufacturing Company, 122 to 132 North Sangamon street, Chicago, Ill., has established a Canadian branch of the McGuire Truck Works at St. Catharines, Ont., in order that it may supply the Canadian trade which the heavy duty on American trucks has hitherto prevented. It has already received an order from the Niagara Falls and River Railway Company, and the trucks will be built at the Canadian works.

The North Shore Traction Company, of Lynn, Mass., has placed the contract for its new car shed with the Berlin Iron Bridge Company, of East Berlin, Conn. The building will be 103 feet in width and 300 feet in length, constructed entirely of iron and brick in order to have the station fireproof. The same company is also making an addition to a car shed for the Wilmington City Railway Company, at Wilmington, Del.

The Ball engines, manufactured by the Ball Engine Company, of Erie, Pa., continue to find favor in electric light and railway work. The following installations have recently been made: The Austin Electric Light Company, Austin, Minn., one 80-h. p. tandem compound engine; Calamut Electric Street Railway Company, Chicago, Ill., four 300-h. p. cross compound engines; the New Horne Building, Pittsburgh, Pa., two 100-h. p. engines; the Frank Jones Building, Cincinnati, O., one engine.

Waterhouse, Gamble & Co., of Hartford and New York, have recently sold a number of lamps for use upon railroad circuits of 500 volts. A new automatic regulator manufactured by this firm is sold in conjunction with the lamps, and each lamp is provided with an automatic cut-out, the whole forming a system of lighting from a circuit of variable E. M. F. at once new, simple and satisfactory. This firm also will soon place upon the market a new wattmeter based upon the application of electrolysis.

Alexander, Barney & Chapin, 20 Cortlandt street, New York, have a special announcement in this issue of THE ELECTRICAL WORLD in regard to brackets, which this firm makes a specialty of. This well known supply house carries in stock at all times the best and finest specialties to be obtained in the line of general electrical supplies, interior fixtures for residence, theatre, church or business houses. In the line of general electric lighting and electric street railway supplies, medical and dental electrical goods, this firm is in the lead.

Among the electric light companies which have recently ordered Reliance safety water columns from the Reliance Gauge Company, of Cleveland, O., are the Canton Electric Light and Power Company, Canton, O., second order; United Electric Light Company, Springfield, Mass.; Springfield Electric Light and Power Company, Springfield, Ill., fourth order; and the Cincinnati Gas Light and Coke Company, Cincinnati, O. Numerous large orders are reported from the cotton mills of New England for the same appliance.

The Indiana Rubber and Insulated Wire Company announce the removal of its office from 242 Madison street, Chicago, to Marion, Ind., from which point it will hereafter transact all business and receive all communications, and where, with telephonic communication with its factory in Jonesboro, a few miles distant, it will be better able to do justice to its rapidly increasing business. The Electric Appliance Company, of Chicago, its general Western agents, will continue to carry a large and complete stock of all sizes as heretofore.

Electrical and Mechanical Engineering and Trading Company.—This company has been recently organized in this city with temporary offices in the Edison Building, 44 Broad street Its personnel is J. H. Vail, president and chief engineer; U. T Fackenthall, vice-president and general manager; Geo. F. Sandt, secretary and treasurer. The business of the company will be in the line of engineering and contracting for complete equipment of electric light, railway and power systems, and furnishing estimates, specifications and plans for all classes of electrical and mechanical work.

Mr. Frank S. De Ronde, manager of the Standard Paint Company, 2 Liberty street, New York, reports increasing sales of the P. & B. paints, varnish and paper. This company has recently completed arrangements with the following firms to handle its goods: Post & Glover, Cincinnati, Ohio; Robbins Electric Company, Pittsburgh, Pa.; Wadworth, Howland & Company (largest house of its kind in New England), Boston, Mass., and Drake, Parson & Whittier Company, Providence, R. I. Mr. De Ronde has left for Chicago, where he will remain some two weeks or more, superintending the installing of his company's exhibit in the Manufacturers' Building, and also in the Electrical Building.

Fibrone.—While the material of the Fibrone-Terraloid Company, of Newark, N. J, is largely used in numerous useful and novelty articles in competition with hard rubber and in many instances with celluloid, the application of it to electrical goods is claimed to be revolutionizing that branch of trade, and from the progressiveness of the company evidenced by its distribution of souvenirs at the convention of the past week, it has so placed itself before the trade with the fact that "Fibrone is cheaper than hard rubber" and an exact imitation of it; it is a perfect non-conductor, and will not expand or contract under ordinary temperatures; can be molded into any shape, and, unlike rubber, can be supplied in any color and in imitation of any natural wood, stone or metal.

Steam Specialties.—In this issue of THE ELECTRICAL WORLD will be found a special announcement of Thompson & Bushnell Company, 120 Liberty street, this city This firm make a specialty of everything in the line of steam specialties. The Bachelder adjustable spring indicator, which was illustrated in THE ELECTRICAL WORLD Feb. 28, is in general use among hundreds of prominent manufacturing concerns, electric light and street railway companies. This instrument is a new departure, contains features which recommend it to all users, combining, as it does, elements of simplicity and efficiency, possessing few working parts, and always being ready for use at any pressure. In the line of rocking grate bars, steam traps, recording pressure gauges, steam and water packing, lubricators, oil cups, steam separators, etc., this firm has always in stock a full and complete line.

The Partridge Carbon Company, Sandusky, O., manufacturer of carbon brushes and plates, is running its factory at its full capacity in order to fill the many orders which it has lately received. This company recently sent out a circular letter on account of complaints which it has received as to the quality of its brushes. Certain traveling salesmen had represented to various railway companies that they could furnish the Partridge brushes, but when delivered they were found to be of another and inferior make The following response was received by the Partridge Carbon Company from Mr. J. B. Wilson, superintendent of the Washington Electric Railway Company, of Washington, Pa. "We have used your brushes for over a year, and find they are all you claim for them. They wear so well that we don't have to buy very often. Below you will find a tracing of the size of a brush that was in constant use for 90 days with three others that stood equally well."

Business Notices.

Transformers rewound and repaired. Write for prices. The Hill Manufacturing Company, Salem, Va.

Oil Filters for sale cheap. Prices on application to Purity Oil Filter Manufacturing Company, 901 Water street, Pittsburgh, Pa.

Battery Cut-out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

The Edwards electric door opener, which is one of the specialties carried in stock by the Ansonia Electric Company, formerly the Electrical Supply Company, corner Randolph street and Michigan avenue, Chicago, is extensively used by the best contractors for the reasons that it is very compact, is suited either for right or left hand doors, and no amount of pressure against the door will prevent it from opening as easily as when there is no pressure. Another specialty manufactured by the Ansonia Electric Company is the Diamond Carbon Battery.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

UNITED STATES PATENTS ISSUED FEB. 28, 1893.

[In Charge of W. A. Rosenbaum, 177 Times Bldg., N. Y.]

492,394. Insulator-Bracket; William N. Eichnerg, Chicago, Ill. Application filed Nov. 28, 1892. An insulator holder having a bracket arm of substantially an S shape, this bracket having laterally projecting arms and serving in combination with the described S shape of the bracket arm.

492,398. Closed Electric Conduit for Railways; Adolph Heiser, Chicago, Ill. Application filed May 31, 1892. In an electric railway conduit the combination of a rail forming one side of the conduit, an adjustable casting and slot closer with springs.

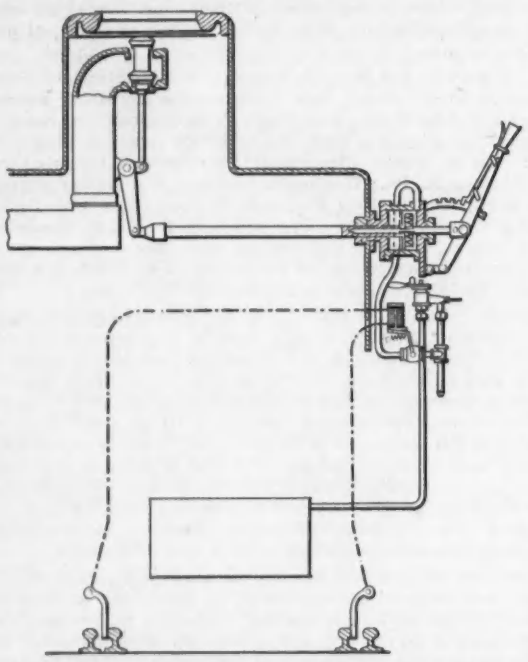
492,402. Electric Train-Controlling Apparatus; Frank E. Kinsman, Plainfield, N. J. Application filed Feb. 24, 1892. The combination of a throttle valve or other power controller, a brake system having a controlling cock, a plunger operating on the throttle, an electromagnet governing the controlling cock, and a connection between the piston of the plunger and a source of air, gas or other pressure, passing through the cock. (See illustration.)

492,403. Means for Operating Throttle-Valves of Steam-Engines; Frank E. Kinsman, Plainfield, N. J. Application filed Feb. 24, 1892. The combination with a motive power controller of a plunger or piston acting on the same in a direction to cut off the motive power from the engine, a manual actuating device having a slip joint and clutch connection with the plunger and controller, and an electromagnet having an armature connected with controlling devices, whereby the plunger may be brought into operation independent of the manual actuating device.

492,422. Battery Jar; James F. McLaughlin, Philadelphia, Pa. Application filed June 2, 1890. A battery jar having a wooden body and metallic corner pieces for this body, constituting terminals for the battery electrodes.

492,456. Switch for Operating Shunt-Wound Electric Motors; Frederick H. Berry, Milwaukee, Wis. Application filed March 3, 1892. The combination of a motor, a sliding contact consisting of plates separated from each other by insulating material, a series of non-movable contacts adapted to be successively engaged by one plate of the sliding contacts with a source of supply, separate non-movable contacts, connected respectively with the field and armature of the motor, the contacts also engaged by the same plate of the sliding contact, and a non-movable contact surface permanently engaged by this last named plate, the contact surface connected with the opposite side of the field and main feed line.

492,457. Electric Railway Block System; Francis O. Blackwell, Boston, Mass. Application filed Feb. 15, 1892. The combination of a supply conductor divided into insulated sections with switches adapted to connect such sections with either pole of the source of supply, and electromagnets controlled by the



No. 492,402.—Electric Train-Controlling Apparatus.

presence of a train on a given section for breaking the normal connection of a succeeding section with the generator and temporarily coupling it to the return conductor.

492,467. Long-Distance Electric Telephony; Charles M. Haynes, Omaha, Neb. Application filed Jan. 12, 1892. In a telephone repeater, the combination with a supporting standard, of a diaphragm within the field of two or more electromagnets with separate circuits, an insulated arm secured at one point to the diaphragm and an adjustable tension spring secured to the arms to counterbalance the attraction of the electromagnets.

492,471. System of Combined Telephony and Telegraphy; Frank A. Pickernell, Newark, N. J. Application filed April 29, 1892. A metallic or double conductor telephone circuit having each of its component conductors centrally divided, and organized to severally constitute the line conductors of independent earth completed telegraphic circuits, combined with a repeater for each such independent telegraphic circuit located at the point of division, and connected with two divided sections whereby each may repeat its signals into and over the other, and with means for maintaining the continuity of the telephone circuit around the repeater.

492,478. Electric Burglar Alarm; Charles F. A. Sturts, San Francisco, Cal. Application filed Sept. 30, 1891. A burglar alarm consisting of an alarm in a bell circuit, and an external circuit including a door lock and one or more places of admission such as a window, the circuit being normally open at such window and closed at such lock when the door is locked, whereby the closing of the circuit at the window will be thrown in the bell circuit and sound a continuous alarm.

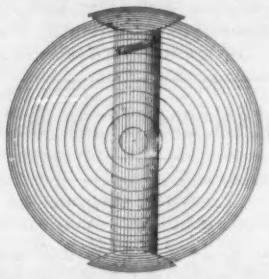
492,480. Transformers and Means for Developing Rotary Magnetic Fields; Charles R. Bradley, Avon, N. Y. Application filed March 17, 1892. A magnetic circuit provided with a closed coil winding tapped at six points and connected through a condenser, a non-inductive conductor and a reaction coil with a simple alternating current circuit to develop a difference of phase and develop a rotation of magnetic poles.

492,482. Signaling Apparatus and Circuit; Edward J. Hall, Morris and Frank A. Pickernell, Newark, N. J. Application filed Oct. 13, 1892. The combination of an electric circuit, and a polarized bell and a magneto telephone included therein, with an alternating current call generator graduated to produce electrical currents adapted to operate the bell, but to which the telephone is irresponsive.

492,483. Busy Signal for Telephone Circuits; Edward J. Hall, Morris and Frank A. Pickernell, Newark, N. J. Application filed Oct. 13, 1892. The combination of a continuation branch or loop circuit, including a telephone transmitter, and provided with a phonograph associated with said transmitter, and adapted for the operation thereof; similar continuation circuit, including an intermittent circuit breaker or current varying device; and a spring-jack or equivalent switchboard connection, containing the terminals of both of the said continuation circuits.

492,484. Telephone Central-Station Circuit; James L. McQuarrie, Boston, Mass. Application filed Sept. 8, 1892. In a metallic circuit multiple switchboard system, a high resistance induction coil bridged in between the tip and sleeve sides of the connecting cords of the operator's keyboard apparatus, the secondary wire of the coil forming a closed circuit and including a polarized clearing out annunciator.

492,492. Electric Car Brake; Wendell C. Fletcher, St. Louis, Mo. Application filed April 15, 1892. The combination with a car brake of an electromagnet whereby said brake is applied; a device for controlling the flow of current through said electromagnet; a retaining device by which the brake is held when applied; a second electromagnet by which said retaining device is released; a circuit controlling said second electromagnet, and devices connected to the circuit controller for the first electromagnet adapted to render the second electromagnet inoperative when the controller is moved to apply the brake and to bring said second electromagnet into operation when the controller is moved to release the brake.



No. 492,512.—Lightning-Rod Ball.

492,493. Automatic Speed Indicator and Recorder; Wendell C. Fletcher, St. Louis, Mo. Application filed April 29, 1892. The combination in a speed indicator, of a dynamo whose speed is proportional to the speed to be indicated; means for maintaining a constant current from the dynamo; and speed indicating devices connected to the regulating means.

492,497. Electric Signaling Apparatus; William H. Kenyon, New York. Application filed June 3, 1892. In a permissive block signal system the combination with a signaling circuit controlling the operation of a precautionary signal guarding a given section consisting of one block and an overlap on the next succeeding block, with a series of double sets of branch circuits and a series of double sets of multiple circuit instruments controlling these branch circuits, arranged to be operated in succession in one direction by trains entering the overlap, and to be operated in reverse succession and direction by these trains on their subsequently and one after another entering the overlap of the next succeeding block and on their leaving same.

492,512. Lightning-Rod Ball; Edward K. Hum, Pittsburgh, Pa. Application filed Sept. 24, 1892. A hollow glass lightning rod ball of true spherical shape, and a tube in two pieces to be inserted in said ball and locked together and having flanges bearing against the exterior of the ball. (See illustration.)

492,519. Electrical Annunciator; John Randolph Hard, New York. Application filed Oct. 8, 1892. The combination with an electromagnet and a spindle mounted to rock in bearings with its axis substantially parallel with the axis of the magnet, an armature spring secured at one end to the spindle and extending radially therefrom and secured at its other extremity to the armature, and a stop pin arranged to take under a part of the armature between the points where the spring is attached respectively to the armature and spindle.

492,524. Electric Motor; Franklin H. Beers, Newark, N. J. Application filed April 2, 1892. In an electric motor having a revolving armature, a field magnet matching closely to such armature and nearly embracing it in cross section in combination therewith, and with arms traversing in a sufficient annular opening, and connecting it with a spider and with commutator bars and connections. (See illustration.)

492,544. Lightning Arrester; Charles F. Scott, Pittsburgh, Pa. Application filed July 29, 1892. In a lightning arrester the combination with an enclosing chamber of one or more movable electrodes, contact plates with which the electrodes are normally in contact and away from which they are thrown by the expansion of the air within the chamber, and a normally interrupted ground circuit.

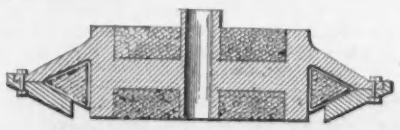
492,545. Electric Signaling Apparatus; Wesley Trafford, New York. Application filed Oct. 17, 1891. The combination with a switch arm and alarm pointer shaft by which it is adjusted, and the spring attached to the shaft, of a detent by which the switch arm and alarm pointer are arrested and released for restoration to their normal positions.

492,547. Thermostatic Fuse Device; Alexander Wurts, Pittsburgh, Pa. Application filed Jan. 14, 1892. The combination with a series of electrodes of zinc or antimony or amalgam or other non-arcing metal presenting to each other diverging faces, and a fusible strip laid against the same.

492,548. Lightning Arrester; Alexander Wurts, Pittsburgh, Pa. Application filed March 12, 1892. In a lightning arrester, confronting electrodes presenting to each other curved surfaces studded with numerous closely assembled points. (See illustration.)

492,549. Lightning Arrester; Alexander Wurts, Pittsburgh, Pa. Application filed Aug. 29, 1892. The combination with an electric generator and its circuit, of lightningarresters for relieving the circuit of lightning charges, and an automatic circuit interrupting device for interrupting the arcs of any or all of the lightning discharge devices.

492,563. Keyed Musical Instrument Actuated by Electricity; Paris E. Singer, London, Eng. Application filed June 17, 1892. In a keyed musical instrument in which electromagnets are used for setting or sustaining the sounding bodies in vibration, the combination therewith of axially moving switches, embraced by elastic contact pieces, situated in the circuit of their respective electromagnets, and electrically connected with the circuits of the lower or upper octave, the fifth or other harmonic division of the scale, and serving to produce octaves or harmonics of the notes sounded by the depression of the keys of the manual.



No. 492,524.—Electric Motor.

492,592. Detecting Apparatus for Coin-Actuating Boxes; George A. Tauberschmidt, Washington, D. C. Application filed Dec. 6, 1892. The combination with a coin controlled receptacle, of an opera glass; an audible signal attached to the glass; means to operate the signal, and a connection between the signal and receptacle for normally holding the signal out of operation.

492,627. Apparatus for Electrically Propelled Cars; Charles J. Kintner, New York, N. Y. Application filed July 30, 1892. An electrically propelled vehicle carrying an electromagnetic alarm device having circuit connections with a circuit interrupter operatively connected to one of the axes of the vehicle, in combination with means for bringing said circuit interrupter into operative relation with the alarm and additional means for locking the interrupter permanently in the latter position.

492,633. Electric Lighting System; Robert W. Rollins, Hartford, Conn. Application filed Aug. 16, 1892. A system of electrical distribution, consisting of two or more independent working circuits, with translating devices placed thereon in series, each circuit having an independent source of electrical energy and cut-out devices adapted for open circuiting any working current when its respective source of energy is inactive and having means for causing the electrical energy belonging to any particular circuit to automatically close such circuit.

492,645. Electric Railway Signal; Howard St. C. Wait, New York, N. Y. Application filed Aug. 11, 1892. The combination of the inclined table having in its surface channel or guides representing a railway track, with balls thereon independently movable in said channels or guides, to represent the movement of trains, and magnetic escapements arranged at intervals on said miniature track to control the movement of the balls.

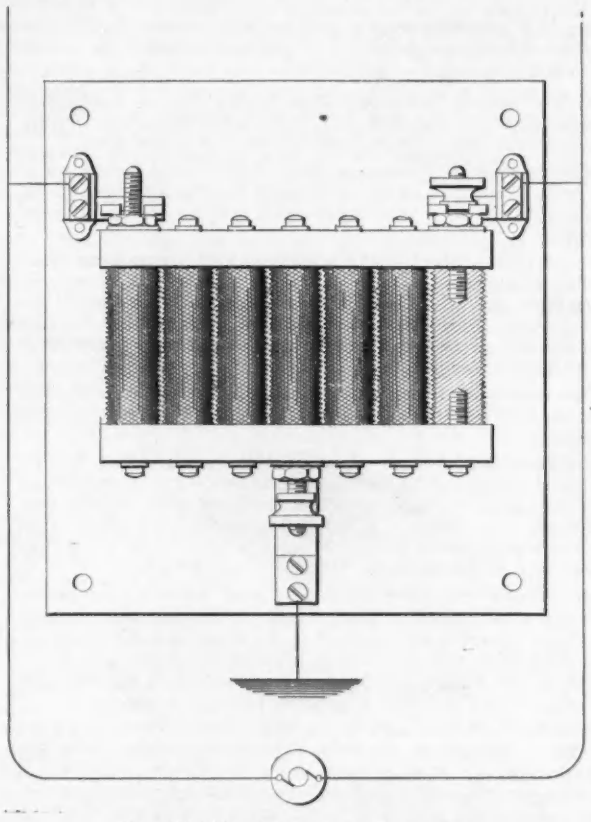
492,646. Electric Alarm for Money Drawers; William J. Walker, St. Louis, Mo. Application filed Oct. 29, 1892. A money drawer having a series of contacts interrupted by space, a handle for said drawer, a contact on said handle co-operating with said contacts and space, a lock for the drawer, and suitable means for operating said lock when the handle is brought opposite the space between the contacts.

492,649. Lightning Arrester; Thomas Wheatley, Wilkes Barre, Pa. Application filed Nov. 14, 1892. In a lightning arrester the combination with the switch lever included in the main circuit of an explosive chamber operatively connected with the said switch lever, and likewise included in the main circuit and adapted to receive an explosive which is ignited on the passage of an abnormal charge of electric fluid to change the relative position of said switch lever and ground the line wire.

492,650. Electric Arc Lamp; William P. Wieman, Allegheny, Pa. Application filed April 18, 1892. In an arc lamp, a counterpoise for the carbon carrier comprising a shaft adapted to be geared to said carrier, and an overbalanced segment pivoted to gear with the shaft.

492,659. Electric Railway; Michelangelo Cattori, Rome Italy. Application filed July 23, 1892. In an electric railway, the combination with the conductor constructed in a series of sections, of a circuit making and breaking switch arranged between each of the sections and having depending diverging arms, and a sliding contact held to slide on the sections, the contact having oppositely extending blades to engage the switch arms and open and close the switch, the blades being wider at one end than at the other, but having, when united, a constant distance between their outer edges.

492,681. Armature for Dynamo Electric Machines; George Hoare, Newark, N. J. Application filed March 24, 1892. In an armature for electric machines, the combination with the armature heads of driving and spacing pins inserted in the heads and extended laterally over the body of the armature core, and a band surrounding the armature and clamping the driving pins in place.



No. 492,548.—Lightning Arrester.

492,689. Relay; Jacob W. Lattig, Easton, Pa. Application filed Nov. 28, 1892. Two independently energized electromagnets and armature levers therefor, in combination with two rocker shafts each having a detent to engage one lever, and a tappet to be operated on by the other lever, for the purpose of throwing the detent in the path of the lever with which it is intended to engage.

492,694. Electric Alarm for Hotels; John McMurrow, Jr., Philadelphia, Pa. Application filed July 21, 1892. An electric alarm consisting of movable insulated strips with openings therein and magnets at the ends thereof, and a time piece having pins with which the hands are adapted to contact, wires connecting the time piece and strips, and pegs connected with wires.

492,713. Welding Metals Electrically; Charles L. Coffin, Detroit, Mich. Application filed Oct. 29, 1892. The mode of heating metal electrically for welding, consisting of subjecting said metal to the action of a voltaic arc at a short distance from the proposed seam, whereby the metal is not changed by the action of the arc at the line of weld.

492,737. Conduit Electric Railway; James H. Bates, Hoboken, N. J. Application filed Aug. 2, 1892. In an electric railway the combination with the slotted conduit of a trolley mounted therein and having the edges of its frame extended or turned downward; wheels supporting the trolley frame and located wholly inside the down-turned edges, and electrical connections extending from the trolley to the car motor and to the feeder.

492,757. Rheostat Plate; Charles E. Carpenter, Bridgeport, Conn. Application filed Oct. 27, 1892. In a rheostat in which the resistance is embedded in the enamel, or its equivalent, a supporting plate which is thicker at the edges than at the centre.

492,758. Rheostat Plate; Charles E. Carpenter, Bridgeport, Conn. Application filed Oct. 27, 1892. A resistance or rheostat, consisting of a base plate provided with ribs or projections, a layer of enamel between said ribs or projections, and a conductor buried in said enamel.

492,770. Railroad Crossing; Wendell C. Fletcher, St. Louis, Mo. Application filed May 27, 1892. The combination with a railway crossing of safeguards for the crossing normally obstructing the approach to the crossing; electric circuits controlling these safeguards; means adapted to close the circuits and clear the approach to the crossing; and means adapted to break these circuits by the setting of safeguards to permit passage across the railway line.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.